PREFACE

Dear Students.....

It gives us immense pleasure in presenting Physics Course Book for our CBSE students, which is first of its kind. The course book prepared systematically in proper sequence and is an excellent supplement for various reference books. We are confident that the book in its present form will be complete in itself and will prove to be a boon to the students for their preparation as per the CCE (New Pattern).

The Unique features are :

- Topic wise synopsis with terminology at the beginning of every chapter.
- Detailed explanation is given for all NCERT Textual Questions.
- Concise and accurate treatment of subject matter as per academic skills.
- Profusely illustrated with examples and well labelled diagrams.
- Topic wise skill based questions are given with solutions to enhance their analytical skills.
- Students are exposed to chapter wise Multiple Choice, Assertion and Reason Type and Passage Type Questions for self assessment and recapitulation.
- Chapter wise exercises will help the student to solve more examples in various models.

Our time-tested approach together with this comprehensive book, which is on par with international standards, will definitely help the students to fulfil their dreams of securing top score in CBSE and top ranks in various competitive examinations at National Level like ISEET (IIT, AIEEE), NEET, AIPMT and Olympiads.

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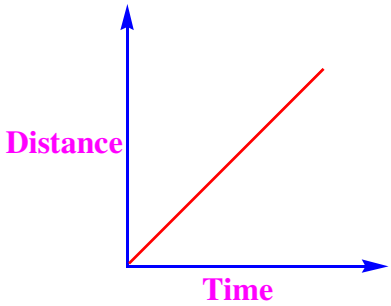
1 MOTION

WISE UP

- When the position of an object relative to the other objects around it does not change, we say that it is at rest.
- An observer judges his surrounding that he himself is at rest.
- When a body moves from one point to another along a straight line or a smooth curve, its motion is called translatory.
- Motion along a straight line is called rectilinear motion and motion along a curved path is called curvilinear motion.
- When an object turns or rotates or spins about an axis passing through itself, its motion is called rotatory.
- A motion that is repeated after a fixed interval of time is called periodic motion.
- Oscillatory motion is the periodic motion of a body about its mean position.
- When a body follows a circular path, it is in circular motion. The position of the body changes continuously, but its distance from the centre of the path remains constant. Also, the direction of its motion changes continuously.
- Motion can be uniform (or) non – uniform motion.
- **Uniform motion:** Equal distance covered in equal intervals of time. It means a constant motion.
- **Non-Uniform motion :** Un equal distance covered in equal intervals of time.
- **Speed :** Distance moved by an object in unit time is called speed.
  - Basic unit of measuring speed is m/s .
- Time is measured with respect to the periodic motion.
  - The basic unit of time is a second. Its symbol is s.
- Distance time graph gives us an idea about the motion of object.

  Straight line obtained on this graph depicts constant motion, while non–constant motion is depicted by various shapes on the graph.
- The distance - time graph for the motion of an object moving with a constant speed is a straight line



NCERT TEXTUAL QUESTIONS

1. An object has moved through a distance. Can it have zero displacement ? If yes, support your answer with an example. (Understanding)

A. Yes, even though an object has moved through a distance it can have zero displacement.

For example if we take a round trip and reach back at the starting point then, though we have travelled some distance, our final (Resultant) displacement will be zero. This is because the straight line distance between initial and final positions will be zero.

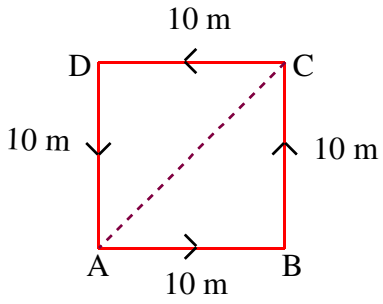
2. A farmer moves along the boundary of a square field of side 10 m in 40 s. What will be the magnitude of displacement of the farmer at the end of 2 minutes 20 seconds from his initial position ? (Applying)

A. Consider a square field as shown in figure initially the position of the farmer is at 'A'.

Side of the square = 10 m.

Number of rotations made in 40 s = 1

$\therefore$ No.of rotations made in 140 s = $3\frac{1}{2}$



The position of the farmer after completion of '$3\frac{1}{2}$' turns is 'C'.

$\therefore$ The displacement of the farmer

$AC^2 = AB^2 + BC^2$

$\Rightarrow AC^2 = 100 + 100$

$\Rightarrow AC^2 = 200$

$\Rightarrow AC = \sqrt{100 \times 2} = 10\sqrt{2}\, m = 14.4$ m

3. Which of the following is true for displacement? (Creating)

a) It cannot be zero.

b) Its magnitude is greater than the distance travelled by the object.

A. a) Is false. If the object takes a round trip, after reaching the initial point, displacement will be zero.

b) Is false. The magnitude of displacement is less than or equal to distance travelled.

4. Distinguish between speed and velocity. (Creating)

A.

Speed	Velocity
1) Speed can be defined as distance travelled by the object in unit time.	1) Velocity of a body is the displacement (resultant) covered per unit time.
2) Average Speed = $\frac{\text{Total distance travelled}}{\text{Total time taken}}$	2) Average Velocity = $\frac{\text{Net Displacement}}{\text{Total time taken}}$
3) Speed has only magnitude i.e, scalar	3) Velocity has magnitude as well as direction i.e, vector
4) SI unit of speed is metre per second (m/s).	4) SI unit of velocity is metre per second (m/s).

5. Under what condition(s) is the magnitude of average velocity of an object equal to its average speed? (Applying)

A. The magnitude of average speed and average velocity of a moving body is equal only if the body moves in a straight line.

6. What does the odometer of an automobile measure? (Understanding)

A. The odometer measures the distance travelled by an automobile.

7. What does the path of an object look like when it is in uniform motion? (Understanding)

A. In uniform motion the object maintain constant speed in a 'straight path'.

8. During an experiment, a signal from a spaceship reached the ground station in 5 minutes. What was the distance of the spaceship from the ground station? The signal travels at the speed of light, that is, 3×10^8m/s. (Applying)

A. The speed of the signal, $v = 3 \times 10^8$ m/s
Time taken by the signal to reach the ground station, t = 5 minutes = 300 s
Distance, S = vt
$= 3 \times 10^8 \times 300$
$= 9 \times 10^{10}$ m.

9. When will you say a body is in (Understanding)

i) uniform acceleration? ii) non-uniform acceleration?

A. i) If an object travels in a straight line and its velocity increases or decreases by equal amount in equal intervals of time, then the acceleration of the object is said to be uniform acceleration.

ii) If the change in velocity is not uniform in equal intervals of time, then the object is said to be in non-uniform acceleration.

10. A bus decreases its speed from 80 kmph to 60 kmph in 5s. Find the acceleration of the bus.

A. Initial speed, u = 80 kmph (Application)

$$= 80 \times \frac{5}{18} ms^{-1} = \frac{200}{9} ms^{-1}$$

Final speed, v = 60 kmph

$$= 60 \times \frac{5}{18} ms^{-1} = \frac{50}{3} ms^{-1}$$

Time taken to change its speed, t = 5s

$\therefore$ acceleration, $a = \frac{v-u}{t}$

$$= \frac{\frac{50}{3} - \frac{200}{9}}{5} = \frac{\frac{150-200}{9}}{5} = \frac{-50^{10}}{9 \times 5}$$

$$= -\frac{10}{9} = -1.11 \text{ ms}^{-2}$$

- Here negative sign indicates bus is in retardation.

11. A train starting from a railway station and moving with uniform acceleration attains a speed 40kmph in 10 minutes. Find its acceleration ? (Applying)

A. Initial speed, u = 0 ms^{-1}

Final speed, v = 40 kmph

$$= 40 \times \frac{5}{18} ms^{-1}$$

$$= \frac{100}{9} ms^{-1}$$

Time taken to change its speed, t = 10 minutes

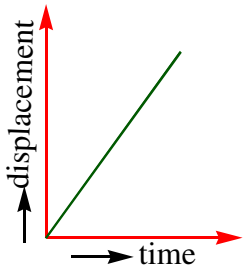
= 600 s

$$\therefore \quad \text{acceleration (a)} \quad = \frac{v-u}{t} = \frac{\frac{100}{9} - 0}{600} = \frac{100}{9 \times 600}$$

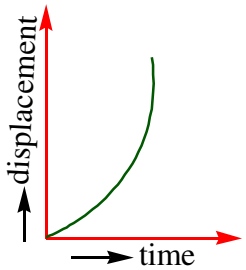
$$= \frac{1}{54} ms^{-2} = 0.0185\ ms^{-2}$$

12. What is the nature of the distance - time graphs for uniform and non-uniform motion of an object? (Analyzing and Evaluating)

A. For uniform speed, distance - time graph is a straight line. While in the case of non-uniform motion it is a curve.



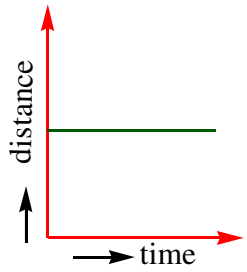
Uniform motion



Non uniform motion

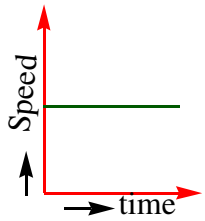
13. What can you say about the motion of an object whose distance - time graph is a straight line parallel to the time axis? (Analyzing and Evaluating)

A. If distance - time graph is a straight line parallel to time axis then the object is at rest.



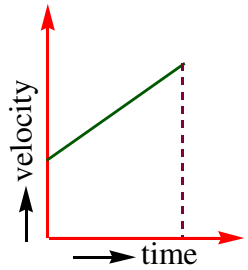
14. What can you say about the motion of an object if its speed - time graph is a straight line parallel to the time axis ? (Analyzing and Evaluating)

A. Object is moving with uniform speed.



15. What is the quantity which is measured by the area occupied below the velocity - time graph? (Analyzing and Evaluating)

A. Area under velocity-time graph gives displacement.



16. A bus starting from rest moves with a uniform acceleration of 0.1 ms^{-2} for 2 minutes find a) the speed acquired b) the distance travelled. (Applying)

A. a) Initial speed, $u = 0\ ms^{-1}$
Acceleration, $a = 0.1\ ms^{-2}$
Time of journey, $t = 2$ minute
$t = 120$ s
Final speed $v = ?$

$\because$ Acceleration, $a = \frac{v-u}{t}$

$\Rightarrow v - u = at$

$\Rightarrow v = u + at$

$= at$ ($\because u = 0$)

$= 0.1 \times 120$

$= 12$ m/s

b) Distance travelled, $s = ?$

$$s = ut + \frac{1}{2}at^2 = \frac{1}{2}at^2 \quad (\because u = 0)$$

$$= \frac{1}{2} \times 0.1 \times 120 \times 120 = 720\,m$$

17. A train is travelling at a speed of 90 kmph, brakes are applied so as to produce a uniform acceleration of – 0.5 ms^{-2}. Find how far the train will go before it is brought to rest. (Applying)

A. Initial speed (u) = 90 kmph

$$= 90 \times \frac{5}{18} = 25 ms^{-1}$$

Final speed (v) = 0 ms^{-1}

Acceleration (a) = –0.5 ms^{-2}

Distance covered before come to rest, s = ?

$\because$ $v^2 - u^2 = 2aS$

$$\Rightarrow \quad S = \frac{v^2 - u^2}{2a} = \frac{0 - (25)^2}{2(-0.5)}$$

$$= \frac{-25 \times 25}{-2 \times 0.5}$$

= 625 m

18. A trolley, while going down an inclined plane, has an acceleration of 2 cm/s^2, what will be its velocity in 3 s after the start? (Applying)

A. Initial velocity, u = 0 ms^{-1}

Acceleration, a = 2 cms^{-2}

Given time interval, t = 3 s

Final velocity, v = ?

$\therefore$ v = u + at

= at ($\because$ u = 0) = 2 × 3 = 6 cm/s

19. A racing car has a uniform acceleration of 4 ms^{-2}. What distance will it cover in 10 s after start? (Applying)

A. Initial velocity of the car, u = 0 ms^{-1}

Uniform acceleration, a = 4 ms^{-2}

Given time period, t = 10 s

Distance covered by it in 10 s, S = ?

$\because$ $S = ut + \frac{1}{2}at^2$

$$= \frac{1}{2}at^2 \qquad (\because u = 0)$$

$$= \frac{1}{2} \times 4 \times 10 \times 10 = 200 \ m$$

20. A stone is thrown in a vertically upward direction with a velocity of 5 ms^{-1}. If the acceleration of the stone during its motion is 10 ms^{-2} in the downward direction, what will be the height attained by the stone and how much time will it take to reach there? (Applying)

A. i) Initial velocity, u = 5 ms^{-1} (upward direction)

Acceleration, a = –10 ms^{-2} (direction)

at maximum height, v = 0 ms^{-1}

$\because$ Maximum height attained by the stone, S = ?

$\because$ $v^2 - u^2 = 2aS$

$$\Rightarrow \quad S = \frac{v^2 - u^2}{2a} = \frac{0-(5)^2}{2(-10)} = \frac{25}{20} = 1.25\,m$$

ii) Time taken to reach maximum height, t = ?

$\because$ v = u + at

$$\Rightarrow \quad t = \frac{v-u}{a} = \frac{-5}{-10} = 0.5\,s\,.$$

NCERT TEXTUAL EXERCISES QUESTIONS

1. An athlete completes one round of a circular track of diameter 200 m in 40 s. What will be the distance covered and the displacement at the end of 2 minutes 20 s? (Applying)

A. The distance covered for one complete round,

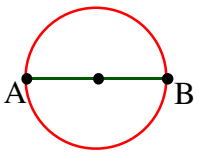
$$S = 2\pi R \quad \left[\because R = \frac{D}{2}\right] \qquad R = \frac{200}{2} = 100\,m$$

$= 2 \times 3.14 \times 100$

= 628 m.

Time taken for one complete round, t = 40 s.

Total time of journey, T = 2 min 20 s = 140 s.



i) Distance covered in 140 s is,

$$S = \frac{140}{40} \times 628$$

= 2198 m.

ii) Displacement in 140 s is S = ?

$$\text{No. turns in 140 s} = \frac{140}{40} = \frac{7}{2} = 3.5$$

After completing $3\frac{1}{2}$ turns athlete reaches diametrically opposite point on the circular track.

$\because$ Displacement, S = AB

= 2R

= 200 m

2. Joseph jogs from one end A to the other end B of a straight 300 m road in 2 min 30 s and then turns around and jogs 100 m back to point C in another 1 minute. What are Joseph's average speeds and velocities in jogging (a) From A to B and (b) From A to C ? (Applying)

A. Distance covered from A to B is = 300 m

Time taken for the journey, t_1 = 2 min 30 s = 150 s

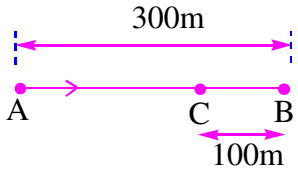
Distance covered from A to C is = 300 m + 100 m = 400 m

Time taken, t_2 = 1 min + 2 min 30 s = 3 min 30 s

a) From A to B :

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$

$$= \frac{300}{150} = 2 ms^{-1}$$



$$\text{Average velocity} = \frac{\text{Net displacement}}{\text{Total time taken}} = \frac{300}{150} = 2\ ms^{-1}$$

b) From A to C :

$$\text{Average speed} = \frac{400}{210} = 1.905 \text{ m/s}$$

$$\text{Average velocity, } = \frac{\text{Net displacement}}{\text{Total time taken}} = \frac{300-100}{210} = \frac{200}{210} = 0.95\ m/s$$

3. Abdul, while driving to school, computes the average speed for his trip to be 20 kmph. On his return trip along the same route, there is less traffic and the average speed is 30 kmph. What is the average speed for abdul's trip ? (Applying)

A. Let the distance between school and home is 's'

Abdul's average speed from home to school, v_1 = 20 kmph

$$\text{Time taken, } t_1 = \frac{S}{v_1} = \frac{S}{20} \text{ hr}$$

Abdul's average speed in return trip, v_2 = 30 kmph

$$\text{Time taken, } t_2 = \frac{S}{v_2} = \frac{S}{30} \text{ hr.}$$

$$\text{For the whole trip, average speed, } v = \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

$$= \frac{2S}{S\left(\frac{1}{20}+\frac{1}{30}\right)} = \frac{2S}{S\left(\frac{3+2}{60}\right)} = 2\times 12$$

$$= 24 \text{ kmph}$$

4. A motorboat starting from rest on a lake accelerates in a straight line at a constant rate of $3ms^{-2}$ for 8 s. How far does the boat travel during this time? (Applying)

A. Initial velocity, u = 0 ms^{-1}

acceleration, a = 3 ms^{-2}

Journey time, t = 8 s

$$\text{distance, } s = ut + \frac{1}{2}at^2$$

$$= \frac{1}{2}at^2 \qquad [\because u = 0]$$

$$= \frac{1}{2}(3)(8)^2 = \frac{1}{2} \times 3 \times 64 = 96 \text{ m.}$$

5. A driver of a car travelling at 52 kmh^{-1} applies the brakes and accelerates uniformly in the opposite direction. The car stops in 5 s. Another driver going at 34 km h^{-1} in another car applies his brakes slowly and stops in 10 s. On the same graph paper, plot the speed versus time graphs for the two cars. which of the two cars travelled farther after the brakes were applied? (Applying)

A. In fig, AB and CD are the speed - time graphs for the two cars whose initial speeds are 52 km/h and 34 km/h, respectively.

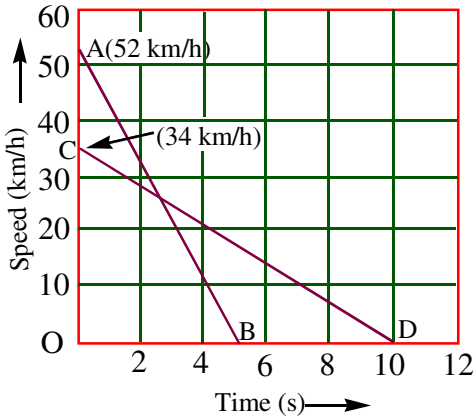
Distance covered by first car before coming to rest

= Area of triangle AOB

$$= \frac{1}{2} \times AO \times BO$$

$$= \frac{1}{2} \times 52\,km/h \times 5\,s$$

$$= \frac{1}{2} \times \frac{52 \times 5}{18} m/s \times 5s = 36.1\,m$$



Distance covered by the second car before coming to rest

= Area of triangle $COD = \frac{1}{2} \times CO \times DO$

$$= \frac{1}{2} \times 34\,km/h \times 10\,s = \frac{1}{2} \times \frac{34 \times 5}{18} m/s \times 10s = 47.2\,m$$

Thus, the second car travelled further than the first car after the brakes were applied.

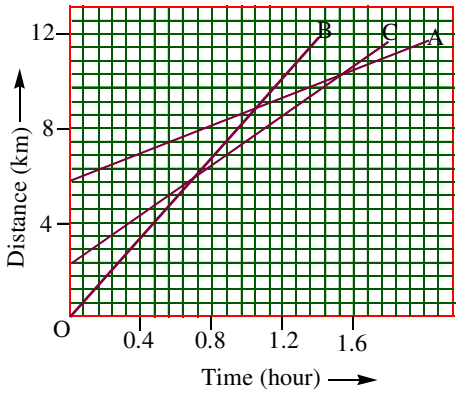
6. Figure shows the distance - time graph of three objects A, B and C. Study the graph and answer the following questions. (Applying)

a) Which of the three is travelling the fastest?

b) Are all three ever at the same point on the road?

c) How far has C travelled when B passess A?

d) How far has B travelled by the time it passes C?



A. Scale on X axis is $\rightarrow \frac{0.4}{5}$

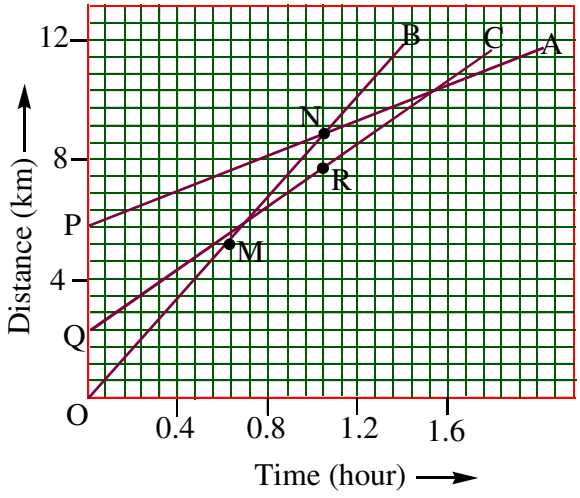
Scale on Y axis is $\rightarrow \frac{4}{7}$

a) Speed of A = Slope of $PN = \frac{8.571 - 5.71}{1.04} = \frac{2.86}{1.04} = 2.75 kmph$

Speed of B = Slope of $OM = \frac{5.14 - 0}{0.64} = \frac{5.14}{0.64} = 8.031\ kmph$

Speed of C = Slope of $QR = \frac{7.43 - 2.28}{1.04} = \frac{5.15}{1.04} = 4.95\ kmph$

Thus, B is travelling the fastest



b) No, all three do not meet at any point on the road

c) When B passes A at point N (at 1.1 hours), C is at a distance of nearly 9 km from the origin O.

d) B passes C at 0.7 hours. During this time B covers distance = 6 km.

7. A ball is gently dropped from a height of 20 m. If its velocity increases uniformly at the rate of 10 ms^{-2}, with what velocity will it strike the ground? After what time will it strike the ground?

A. Here , u = 0ms^{-1}, S = 20m, a = 10ms^{-2}, v = ? t = ? **(Applying)**

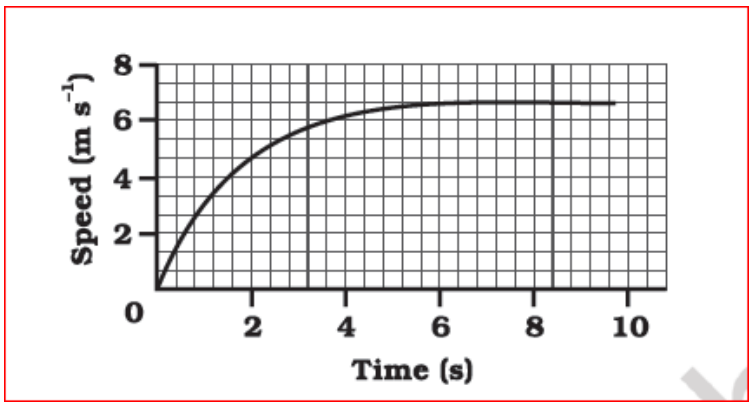
As $v^2 - u^2 = 2aS$

$\therefore$ $v^2 - 0^2 = 2 \times 10 \times 20 = 400$

or $v = 20\ ms^{-1}$

and $t = \frac{v-u}{a} = \frac{20-0}{10} = 2\,s$

8. The speed - time graph for a car is shown in figure. **(Applying)**



a) Find how far does the car travel in the first 4 s. Shade the area on the graph that represents the distance travelled by the car during the period.

b) Which part of the graph represents uniform motion of the car?

A. a) On horizontal axis, 5 small divisions = 2 s

On vertical axis, 3 small divisions = 2 ms^{-1}

$\therefore$ Area of 15 small squares = 2 s × 2 ms^{-1} = 4 m

Area of 1 small square $= \frac{4}{15} m$

Total area under the speed - time graph from time 0 to 4 s

$= 57$ small squares $+ \frac{1}{2} \times 6$ small squares = 60 small squares

Distance travelled by the car in first 4 s

= Area under the speed - time graph from 0 to 4 s = 60 small squares

$= 60 \times \frac{4}{15} m = 16$ m.

b) After 6 s, the car has a uniform motion

9. State which of the following situations are possible and give an example for each of these:

a) an object with a constant acceleration but with zero velocity (Understanding)

b) an object moving with an acceleration but with uniform speed.

c) an object moving in a certain direction with an acceleration in the perpendicular direction.

A. a) Yes, a body can have acceleration even when its velocity is zero. When a body is thrown up, at highest point its velocity it zero but is has acceleration equal to acceleration due to gravity.

b) Yes, a body moving in uniform circular motion, it has acceleration because direction of motion changes continously but its speed is constant

c) Yes, An aeroplane moving horizontally is acted upon by acceleration due to gravity that acts vertically downwards.

10. An artificial satellite is moving in a circular orbit of radius 42250 km. Calculate its speed if it takes 24 hours to revolve around the earth. (Applying)

A. Given,

$r = 42,250 \text{ km} = 42,250 \times 1000\text{m}$

$T = 24 \text{ h} = 24 \times 60 \times 60 \text{ s}$

Speed, $v = \frac{2\pi r}{T}$

$= \frac{2 \times 3.14 \times 42,250 \times 1000}{24 \times 60 \times 60} m/s$

$= 3070.9 \text{ m/s} \simeq 3.07\ km/s$

TEXT BOOK SOLVED PROBLEMS

1. An object travels 16 m in 4 s and then another 16 m in 2s. What is the average speed of the object ? (Applying)

A. Total distance travelled by the object = 16 m + 16 m = 32 m

Total time taken = 4 s + 2 s = 6s

$$\text{Average speed} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

$$= \frac{32m}{6s} = 5.33 ms^{-1}$$

Therefore, the average speed of the object is 5.33 ms^{-1}.

2. The odometer of a car reads 2000 km at the start of a trip and 2400 km at the end of the trip. If the trip took 8 h, calculate the average speed of the car in km h^{-1} and ms^{-1}. (Applying)

A. Distance covered by the car,

s = 2400 km – 2000 km = 400 km

Time elapsed, of the car is, 8h

$$V_{avg} = \frac{s}{t} = \frac{400km}{8h} = 50 \text{ kmh}^{-1}$$

$$= 50 \times \frac{5}{18} \text{ ms}^{-1}$$

$$= 13.9 \text{ ms}^{-1}$$

The average speed of the car is 50 kmh^{-1} or 13.9 ms^{-1}.

3. Usha swims in a 90 m long pool. She covers 180 m in one minute by swimming from one end to the other and back along the same straight path. Find the average speed and average velocity of Usha. (Applying)

A. Total distance covered by Usha in 1 min is 180 m.

Displacement of Usha in 1 min = 0 m

$$\text{Average speed} = \frac{\text{Total distance covered}}{\text{Total time taken}}$$

$$= \frac{180m}{1min} = \frac{180m}{60s} = 3ms^{-1}$$

$$\text{Average velocity} = \frac{Displacement}{Total\ time\ taken} = \frac{0m}{60s} = 0ms^{-1}$$

The average speed of Usha is 3 ms^{-1} and her average velocity is 0 ms^{-1}.

4. Starting from a stationary position, Rahul paddles his bicycle to attain a velocity of 6 ms^{-1} in 30 s. Then he applies brakes such that the velocity of the bicycle comes down to 4 ms^{-1} in the next 5 s. Calculate the acceleration of the bicycle in both the cases. (Applying)

A. In the first case :

Initial velocity, u = 0 ;

Final velocity, v = 6 ms^{-1};

Time, t = 30 s.

We have

$$a = \frac{v-u}{t}$$

Substituting the given values of u, v and t in the above equation, we get

$$a = \frac{(6ms^{-1} - 0ms^{-1})}{30s}$$

$$= 0.\ 2\ ms^{-2}$$

In the second case :

Initial velocity, $u = 6\ ms^{-1}$;

Final velocity, $v = 4\ ms^{-1}$;

Time, t = 5 s.

Then, $a = \frac{(4ms^{-1} - 6ms^{1})}{5s}$

$$= -0.4\ ms^{-2}.$$

The acceleration of the bicycle in the first case is $0.2\ ms^{-2}$ and in the second case, it is $-0.4\ ms^{-2}$.

5. A train starting from rest attains a velocity of 72 kmh^{-1} in 5 minutes. Assuming that the acceleration is uniform, find (i) the acceleration and (ii) the distance travelled by the train for attaining this velocity. (Applying)

A. We have been given u = 0; $v = 72\ kmh^{-1} = 20\ ms^{-1}$ and t = 5 minutes = 300 s.

i) we know that

$$a = \frac{(v-u)}{t}$$

$$= \frac{20ms^{-1} - 0ms^{-1}}{300s} = \frac{1}{15} ms^{-2}$$

ii) we have

$2a\ s = v^2 - u^2 = v^2 - 0$

Thus, $s = \frac{v^2}{2a}$

$$= \frac{(20ms^{-1})^2}{2 \times (1/15) ms^{-2}}$$

$$= 3000\ m = 3\ km$$

The acceleration of the train is $\frac{1}{15} ms^{-2}$ and the distance travelled is 3 km.

6. A car accelerates uniformly from 18 kmh^{-1} to 36 kmh^{-1} in 5 s. (Applying)
Calculate : (i) the accelration and
(ii) the distance covered by the car in that time.

A. We are given that

u = 18 kmh^{-1} = 5 ms^{-1}

v = 36 kmh^{-1} = 10 ms^{-1}

t = 5 s.

i) we have

$$a = \frac{v-u}{t} = \frac{10ms^{-1} - 5ms^{-1}}{5s} = 1ms^{-2}$$

ii) we have

$$s = ut + \frac{1}{2}at^2$$

$$= 5 \text{ ms}^{-1} \times 5\text{s} + \frac{1}{2} \times 1 \text{ ms}^{-2} \times (5 \text{ s})^2$$

$$= 25 \text{ m} + 12.5 \text{ m} = 37.5 \text{ m}$$

The acceleration of the car is 1 ms^{-2} and the distance covered is 37.5 m.

7. The brakes applied to a car produce an acceleration of 6 ms^{-2} in the opposite direction to the motion. If the car takes 2 s to stop after the application of brakes, calculate the distance it travels during this time. (Applying)

A. We have been given a = –6 ms^{-2} ; t = 2 s and v = 0 ms^{-1}.

we know that v = u + at

0 = u + (–6 ms^{-2}) × 2 s (or) u = 12 ms^{-1}.

we have $s = ut + \frac{1}{2}at^2$

$$= (12 \text{ ms}^{-1}) \times (2\text{s}) + \frac{1}{2} (-6 \text{ ms}^{-2}) (2 \text{ s})^2 = 24 \text{ m} - 12 \text{ m} = 12 \text{ m}$$

Thus, the car will move 12 m before it stops after the application of brakes.

ADDITIONAL QUESTIONS

I. COMPETENCY - DEMONSTRATE KNOWLEDGE AND UNDERSTANDING

1. Define distance and displacement .

A. **Distance :** The length of the path covered by the object is called distance.

Displacement : The shortest distance measured from the initial to the final position of an object is known as the displacement.

2. Define uniform speed and uniform velocity

A. **Uniform speed :** If an object covers equal distances in equal time intervals, however small the intervals be, it is said to be move with uniform speed.

Uniform velocity : If the object covers equal displacements in equal intervals of time then the object is said to be move with uniform velocity

3. Define acceleration and retardation ?

A. **Acceleration :** If the body is moving with increasing velocity in unit time then the body is said to be move with acceleration.

Retardation : If the body is moving with decreasing velocity in unit time then the body is said to be move with retardation.

4. What is a circular motion ? Give three examples of circular motion ?

A. When an object moves in a circular path, its motion is called circular motion.

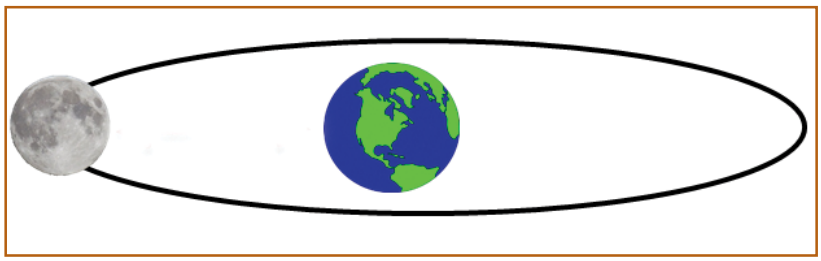
During circular motion, the direction of motion at any point is given by the tangent drawn at that point

Examples :

i) Earth and the other planets move around the Sun in a circular path.

ii) A stone tied to a strong string when rotated gives rise to circular motion of the stone.

iii) Moon moves around the earth in a circular path.



5. State the meaning of uniform circular motion.

A. If an object revolves in a circular path with constant speed, it is known as uniform circular motion.

6. What are the uses of graphical study of motion ?

A. i) From distance -time graph the position of the body at any instant of time can be determined.

ii) Distance covered by the body during particular interval of time can be seen from the graph.

iii) The velocity of the body at any instant of time can be determined.

iv) By simply looking at the graph, one can tell whether motion is uniform or not.

v) Slope of velocity - time graph gives the acceleration of the body

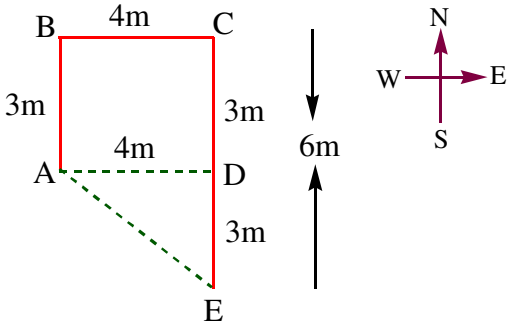
vi) Graphs are very useful for comparing the motions of two moving bodies. Distance time graphs easily tell when and where one body crosses the other body.

7. Show that rest and motion are relative terms ?

A. An object may be at rest relative to one surrounding object and at the same time it may be in motion relative to some other object. For example, a passenger sitting in a moving train is at rest relative to other passengers of his compartment. But since he is sharing the motion of the train, so he is in motion relative to the outside trees, lamp posts, railway stations etc. Thus, rest and motion are relative terms.

8. A particle moves 3m north, then 4 m east and finally 6m south, calculate the displacement.

A. Displacement



$AE^2 = AD^2 + DE^2$

$= (4)^2 + (3)^2$

$= 16 + 9 = 25$

$AE^2 = 25$

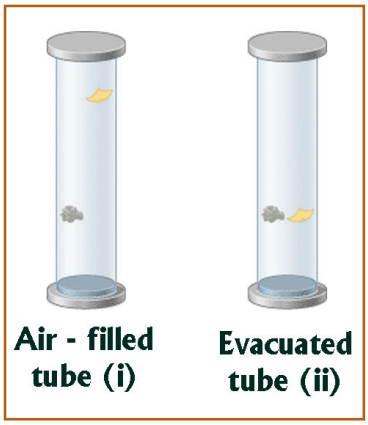
$AE = \sqrt{25}\, m$

= 5 m South of East

9. A sheet of paper and a crumpled paper are thrown down from the same height and time is noted. Answer the following questions.

a) Will the time taken to reach the bottom of the container be the same for the sheet of paper and crumpled paper? Explain ?

b) What will happen in case (i) in air (ii) in vaccum Explain ?



A. a) Not same, crumpled one will reach earlier because air resistance on it is low compared to sheet has large area.

b) i) In air crumpled paper experence less air resistance so it falls earlier than sheet of paper.

ii) In a vacuum chamber there is no air resistance, thus both will reach the bottom in the same time.

10. Mention the uses of a distance - time graph.

A. i) It tells the position of the body at any instant of time.

ii) The distance covered by the body during a particular interval of time can be seen from the graph.

iii) The velocity of the body at any instant of time can be determined.

11. Mention the uses of a velocity - time graph.

A. i) To determine the speed of a body at any instant of time.

ii) To determine the acceleration of a body.

iii) To determine the total distance travelled by a body in a given time interval.

12. Can the direction of velocity of an object reverse when it's acceleration is constant? If so give an example; if not, explain why.

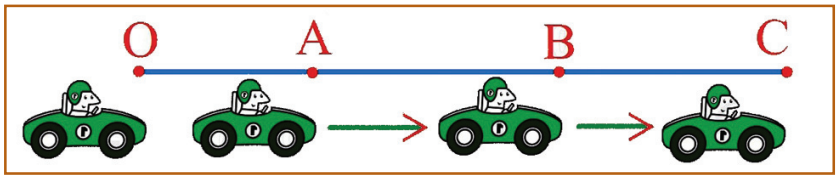
A. Yes, the direction of velocity of an object can be reversed even though it has constant acceleration. When a body is projected vertically up into the air it moves up with constant acceleration with direction towards the centre of earth. At the point of projection it has its velocity in upward direction at the maximum height its velocity becomes zero and direction of velocity is reversed and body moves towards earth.

13. What is the displacement of the body if returns to same point where it is started? Give one example in daily life.

A. If a body returns to same point where it is started then the displacement becomes zero. In daily life when bodies projected vertically up into the air they reach the point of projection after some time.

14. When do the distance and magnitude of displacement become equal?

A. When a body is moving along straight line we can have the distance travelled and magnitude of displacement becoming equal.



15. When does the average velocity become zero?

A. Average velocity of a body is the ratio between displacement produced and time taken.

i) If body remains in rest position

ii) If body reaches the starting position in a given interval of time, we can take the displacement as zero and we can have a chance for average velocity to become zero.

16. If an athlete runs in a circular path of radius 'r' with speed v and completes one rotation in 't' seconds. Then explain, is the motion of an athelet is uniform (or) not and write the expression for his speed.

A. Athelete moving in circular path with constant speed 'v' but his direction of motion is changes continuously, so his motion is not uniform, it is accelerated motion.

$$v = \frac{\text{distance}}{\text{time}} = \frac{2\pi r}{t}.$$

II. COMPETENCY - APPLICATION OF KNOWLEDGE/CONCEPTS

1. State the SI unit of speed. A girl moves with the speed of 6 km/h for 2h and with the speed of 4km/h for the next 3h. Find the average speed of the girl and the total distance moved.

A. The SI unit of speed is m/s

$v_1 = 6$ km/h , $t_1 = 2$ h , $v_2 = 4$ km/h , $t_2 = 3$ h

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$

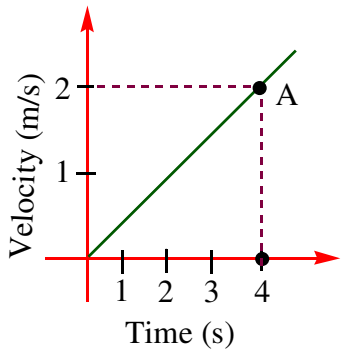
$$v_1 = \frac{s_1}{t_1} \Rightarrow s_1 = v_1 t_1 = 6 \times 2 = 12\,km$$

$$v_2 = \frac{s_2}{t_2} \Rightarrow s_2 = v_2 t_2 = 4 \times 3 = 12\,km$$

$$\text{Average speed} = \frac{s_1 + s_2}{t_1 + t_2} = \frac{12+12}{2+3} = \frac{24}{5} = 4.8 \text{ km/h}$$

Total distance = $s_1 + s_2 = 12 + 12 = 24$ km.

2. The velocity-time graph of a particle of mass 50 g moving in a definite direction is shown in the following figure. Answer the questions based on this figure.



a) What is the velocity of the particle at point 'A'

A. 2m/s

b) Find the momentum of the particle, at time t = 4 s

$$m = 50g = \frac{50}{1000} = 0.05\,kg$$

p = mv = 0.05 × 2 = 0.1 kgm/s

c) What does the slope of graph represent ?

A. Uniform acceleration (or) variable velocity

d) Calculate the displacement travelled in 4 s

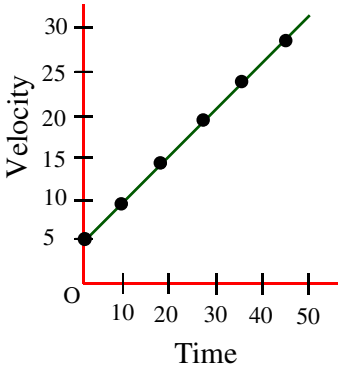
A. Displacement (Area of v – t graph) = $\frac{1}{2} \times 4 \times 2 = 4\ m$

3. A car is moving on a straight road with a uniform acceleration. The following table gives the velocity of the car at various instants of time.

Time (s)	0	10	20	30	40	50
Velocity (m/s)	5	10	15	20	25	30

i) Draw the shape of speed - time graph representing the above sets of observations.

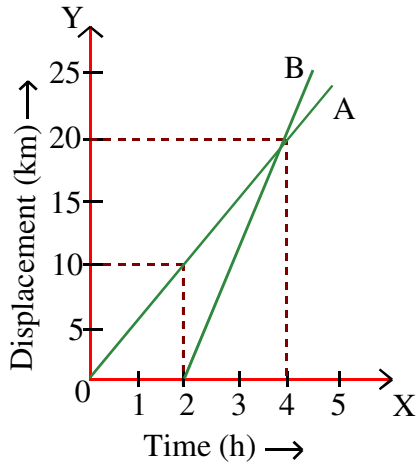
A.



ii) Find the acceleration of the car.

A. Acceleration (a) = $\frac{v-u}{t} = \frac{10-5}{10} = \frac{5}{10} = 0.5\ m/s^2$

4. Figure shows the displacement - time graph for the motion of two boys A and B along a straight road in the same direction.



i) When did B start after A ?

A. B started his motion 2 h later from the start of A.

ii) How far away was A from B when B started ?

A. When B started, A was at distance 10 km away from B.

iii) Which of the two has greater velocity ?

A. B has greater velocity than A since the straight line on graph for B has greater slope than that for A.

iv) When and where did B overtake A ?

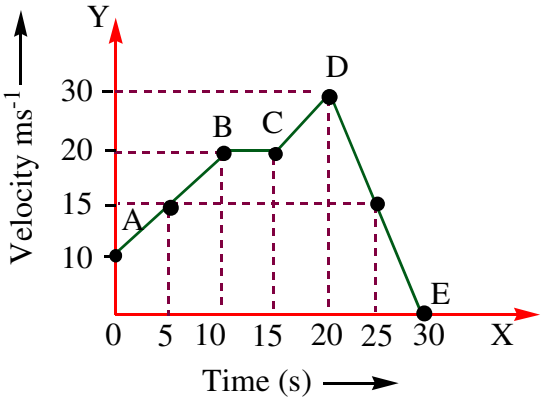
A. B overtook A at the instant when both were at the same place. This position is at the point where the two straight lines meet each other. At this point distance from the starting point is 20 km and time is 4 h. Thus B overtook A when A has travelled for 4 h (or B has travelled for 4 - 2 = 2 h) at distance 20 km from the starting point.

5. The following table represents the velocity of a moving body at different instants of time.

Time (s)	0	5	10	15	20	25	30
Velocity ($m\ s^{-1}$)	10	15	20	20	30	15	0

i) Draw the velocity-time graph

A. The velocity-time graph is



ii) For which interval of time the body has a uniform motion ? Find the velocity in this time interval?

A. The body has uniform motion from t = 10 s to t = 15 s in part bc since velocity is constant and is equal to 20 m s^{-1} during this interval.

iii) For which interval of time the body has the accelerated motion? Calculate the acceleration.

A. The body has the accelerated motion from t = 0 s to t = 10 s in part **"AB"** and also from t = 15 s to t = 20 s in part **"CD"** since velocity is increasing with time during these intervals.

From t = 0 to t = 10 s, in part **"AB"**

Acceleration (a) = slope of the straight line **"AB"**

$$\frac{(20-10)}{(10-0)} = \frac{10}{10} = 1 \text{ m s}^{-2}$$

From t = 15 s to t = 20 s, in part **"CD"**

Acceralation (a) = Slope of the line **"CD"**

$$\frac{(30-20)}{(20-15)} = \frac{10}{5} = 2ms^{-2}$$

iv) For which interval of time, the body has retardation ? Calculate the retardation.

A. The body has retardation from t = 20 s to t = 30 s, in part de.

Retardation = – Slope of the line de

$$= \frac{-(0-30)}{(30-20)} = \frac{30}{10} = 3ms^{-2}$$

6. A racing car has a uniform acceleration of 2 m/s^2 what distance will it cover in 5 s after start?

A. a = 2 m/s^2, u = 0 ms^{-1}, t = 5 s, S = ?

$$S = ut + \frac{1}{2}at^2$$

$$S = \frac{1}{2} \times 2 \times (5)^2 = 25 \text{ m}$$

7. A train 100 m long is moving with a velocity of 60 kmph. Find the time it takes to cross the bridge 1 km long.

A. Total distance covered by the train to cross the bridge = length of train + length of bridge.

d = 0.1 km + 1 km

d = 1.1 km.

velocity (v) = 60 kmph

Time taken to cross the bridge, $t = \frac{s}{v} = \frac{1.1}{60}$

$= 0.0183$ hr $= 66$ s

8. a) A car accelerates uniformly from 18 kmph to 36 kmph in 5 s. Calculate:

i) Acceleration

ii) Distance covered by the car in that time.

b) The length of minute hand of a clock is 14 cm calculate the speed with which the tip of the minute hand moves.

A. a) u = 18 kmph

$= 18 \times \frac{5}{18} = 5\ ms^{-1}$

v = 36 kmph

$= 36 \times \frac{5}{18} = 10\ ms^{-1}$

t = 5 s

i) $\because$ The acceleration, $a = \frac{v-u}{t} = \frac{10-5}{5} = 1\ ms^{-2}$.

ii) Distance covered by the car, s $= 2\pi R$ (in one hr)

$= 2 \times 3.14 \times 14 = 88$ cm $= 0.88$ m.

b) Speed $= \frac{\text{distance}}{\text{time}} = \frac{0.88}{3600} = 2.44 \times 10^{-4}\ m/s$

9. An object starting from rest travels 20 m in first 2 s and 160 m in next 4 s. What will be the velocity after 7 s from the start ?

A. We have, $S = ut + \frac{1}{2}at^2$

In first 2 s, S = 20 m; u = 0 ms^{-1}

$$20 = ut + \frac{1}{2}at^2 \Rightarrow 20 = 0 + \frac{1}{2}a(2)^2 \Rightarrow 20 = \frac{1}{2}a \times 4$$

$a = 10\ m/s^2$

Velocity at the end of 2s is, $v = u + at \Rightarrow v = 0 + 10 \times 2 = 20\ m/s$

In next 4s,

$S = ut + \frac{1}{2}at^2$

$$160 = 20 \times 4 + \frac{1}{2}(a)^1 (4)^2 \Rightarrow a = 10 \text{ m/s}^2$$

It shows that acceleration is uniform

From $v = u + at$

$v = 0 + 10 \times 7 = 70$ m/s

10. The speedometer of the car indicates a constant reading. Is the car in uniform motion? Explain.

A. If speedometer of the car indicates constant reading then we say car is moving with constant speed. We are not certain about the direction of motion. So we cannot consider this as uniform motion.

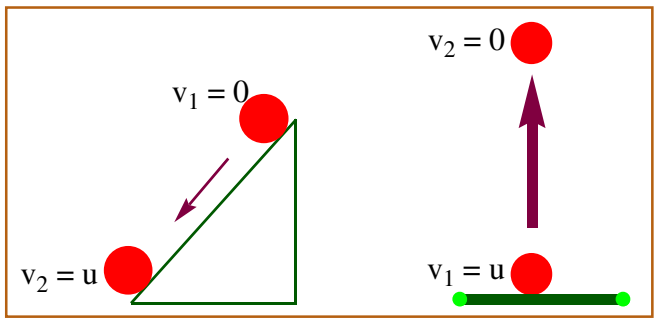
11. An ant is moving on the surface of a ball. Does it's velocity change or not? Explain.

A. As an ant is moving on the surface of a ball it's direction of motion changes from point to point so its velocity changes continuously due to change in magnitude or direction.

12. Give an example of motion where there is a change only in speed but no change in direction of motion.

A. i) When a body is sliding down along an inclined plane we get changing the magnitude of speed only but not direction.

ii) The body which is projected up vertically travels with changing only magnitude of speed but not direction until it reaches maximum height.

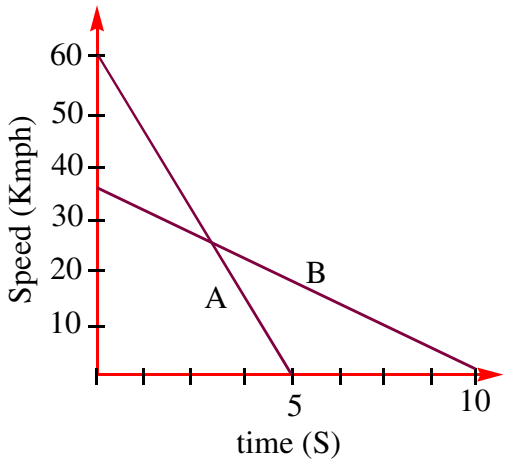


13. What is the acceleration of the race car that moves at constant velocity of 300 km/h ?

A. When a race car is said to be moving along the track with constant velocity of 300 km/h. The direction as well as magnitude of velocity must be considered to be unchanged. So there is no chance for acceleration.The acceleration must be zero.

14. The driver of a train A travelling at a speed of 60 km/h applies brakes and retards the train uniformly, the train stops in 5 s. Another train B is travelling on the parallel track with a speed of 36 kmph. This driver also applies the brakes and the train retards uniformly. The train B stops in 10 s. Plot speed - time graph for both the trains on the same paper. Also calculate the distance travelled by each train after the brakes were applied.

A.



Distance travelled by train A = area

$$= \frac{1}{2} \times 5 \times 60 \times \frac{5}{18} = 41.6 \text{ m}$$

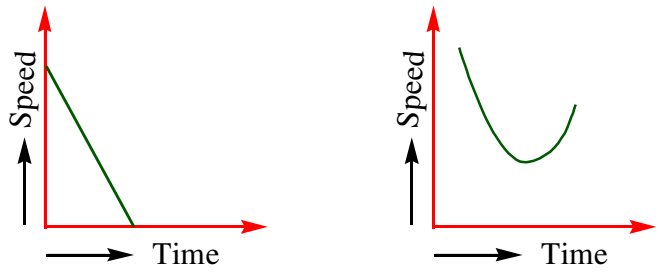
Distance travelled by train $B = \frac{1}{2} \times 10 \times 36 \times \frac{5}{18} = 50$ m

III. COMPETENCY - FORMULATE, ANALYZE, EVALUATE AND CREATE

1. Why the motion of an athlete moving along the circular path is an accelerated motion?

A. During motion along circular path direction changes continuously, thus velocity changes (Even though speed is constant)

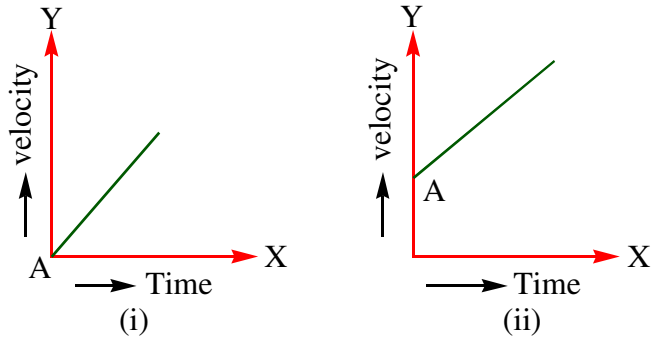
2. What do the graphs shown below indicate:



A. i) Uniform retardation

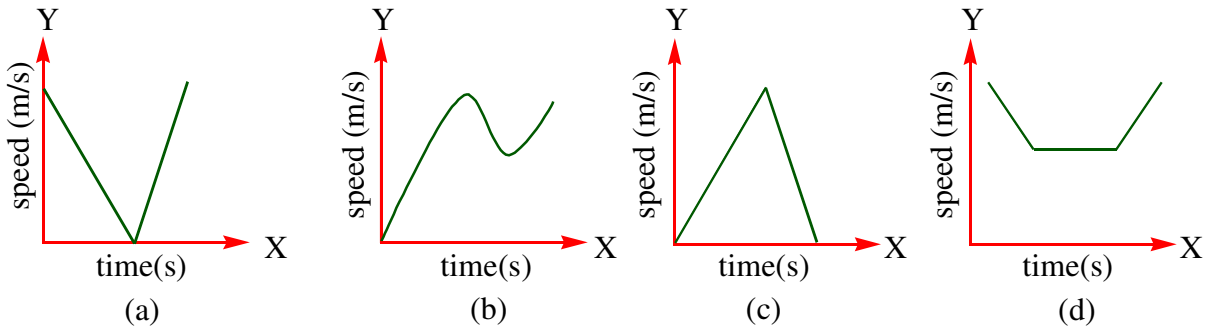
ii) Non uniform acceleration

3. Explain the differences between the two graphs given below.



A. i) Uniform acceleration, body started from rest.
ii) Uniform acceleration, body started with some initial velocity.

4. Four speed - time graphs are shown below.



Which graph represents the following case?

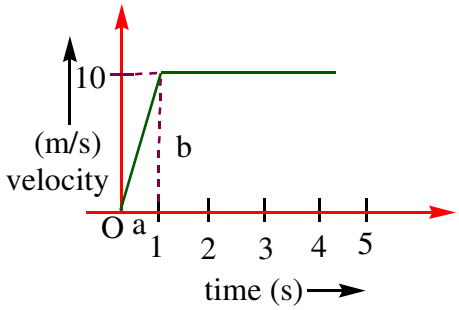
a) A ball thrown vertically upwards and returning to the hand of the thrower?

b) A body decelerating to a constant speed and thus accelerating

A. a) Graph (a)

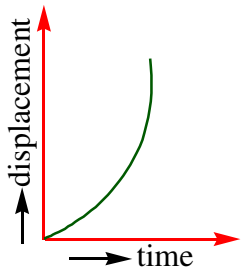
b) Graph (d)

5. Velocity of a particle moving along a straight line in a certain time interval is shown below. What is the distance travelled during acceleration?



A. Distance $= \frac{1}{2}ab = \frac{1}{2} \times 1 \times 10 = 5$ m

6. What is the nature of the displacement-time graph for accelerated motion?



A. It is a curved line because change in displacement is not uniform with time.

7. An object starts with initial velocity u and attains a final velocity of v. The velocity of the object is changing at a uniform rate. Write the formula for calculating the average velocity v_{avg}

A. $v_{avg} = \frac{u+v}{2}$

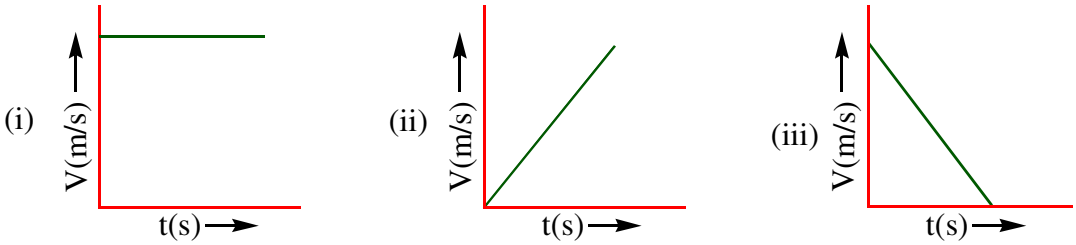
8. The brakes applied to a car produces an acceleration of 6 m/s² in the opposite direction to the motion. If the car takes two seconds to stop after the application of brakes, calculate the distance it travels during this time.

A. **Hint:** $S = ut + \frac{1}{2}at^2 = (v - at)\,t + \frac{1}{2}at^2 = vt - \frac{1}{2}at^2$

$a = -6\ ms^{-2}$, $t = 2s$, $v = 0$

$S = 0 + \frac{1}{2} \times 6 \times 2^2 = 3 \times 4 = 12\ m$

9. What can you conclude about the motion of a body depicted by the velocity-time graphs (i), (ii) and (iii) given below:



A. i) Uniform velocity
ii) Unifrom acceleration
iii) Uniform decelartion

10. Can distance be negative ?

A. No, distance can never be negative

11. Can displacement be negative.

A. Yes, displacement can be negative

12. What does the slope of a velocity - time graph indicate ?

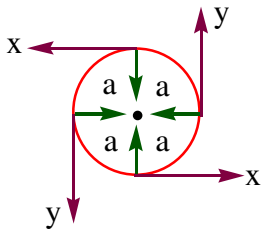
A. The slope of velocity - time graph represents acceleration of the body

13. Name the two quantities, the slope of whose graphs gives (i) Speed ii) Acceleration

A. i) The slope of distance - time graph represents speed of the body

ii) The slope of velocity - time graph represents acceleration of the body.

14. If the acceleration of the particle is constant in magnitude but not in direction, what type of path does the particle follow?



A. If the particle is in uniform circular motion, direction of acceleration is always towards its centre, but magnitude is constant.

15. Two objects of masses M_1 & M_2 are dropped in vacuum from a height above the surface of earth (M_1 is greater than M_2). Which will reach the ground first and why?

A. In vacuum time of decent is same for all masses (independent of mass). Thus both will reach the ground in same time.

QUICK REVIEW

- **Reference point :** It is a point in space with respect to which the position of an object in space is expressed.
  - To describe the position of an object we need to specify a reference point called the origin.
- **Rest :** If the position of an object does not changes as time passes with respect to a reference point, it is said to be at rest.
- **Motion :** If the position of an object changes as time passes with respect to a reference point, it is said to be in motion.
  - Rest & Motion are not absolute, they are relative.
  - Objects may move in a straight line or in a circular path.
  - An object may also exhibit rotatory and vibratory motions.
- **Distance :** The length of the path covered by the object is called distance.
  - Distance has only magnitude, it is a scalar physical quantity. SI unit is metre (m).
- **Displacement :** The shortest distance measured from the initial to the final position of an object is known as the displacement.
  - Displacement is independent of the path followed.
  - Displacement is a vector physical quantity - SI unit is metre (m).
  - Magnitude of displacement is less than or equal to distance.
  - The displacement for a course of motion may be zero but the corresponding distance covered is not zero.

➢ **Speed :** The speed of an object is equal to the distance travelled by it in a short time interval divided by the time interval.

- The speed of an object is the distance covered by it per unit time.
- Speed has only magnitude. SI unit is ms^{-1}. Other practical units are cms^{-1}, kmh^{-1}.
- **Speed** $= \dfrac{\text{distance}}{\text{time}}$

➢ **Uniform speed :** If an object covers equal distances in equal time intervals, however small the intervals be, it is said to be move with uniform speed.

➢ **Non - Uniform speed :** If an object does not cover equal distances in equal time intervals,its speed is called non uniform speed.

➢ **Average speed :** The average speed of an object is obtained by dividing the total distance travelled by the total time taken.

- **Average speed** $= \dfrac{\text{Total distance}}{\text{Total Time}}$.

➢ **Velocity :** The velocity of an object is a quantity that gives the speed of the object as well as its direction.

- The velocity of an object is its displacement per unit time.
- **Velocity** $= \dfrac{\text{Distance}}{\text{Time}}$.
- Velocity is a vector quantity. SI unit is ms^{-1}.
- **Average velocity** $= \dfrac{\text{initial velocity} + \text{final velocity}}{2} \Rightarrow v_{avg} = \dfrac{u+v}{2}$

➢ **Uniform velocity :** If the object covers equal displacements in equal intervals of time then the body is said to be moving with uniform velocity

(or)

If the velocity of an object does not change as time passes, it is said to move with a uniform velocity.

- If velocity is constant object is in uniform motion.
- If the object undergoes unequal displacements in equal time intervals, the motion is non uniform.
- Velocity can be changed by changing the object speed or direction of motion or both.

➢ **Acceleration :** When the motion is non-uniform, the object is said to have an 'acceleration'.

- Acceleration is the change in velocity per unit time.
- Acceleration is a vector quantity. SI unit ms^{-2}.
- $a = \dfrac{v-u}{t}$ $u \rightarrow$ initial velocity, $v \rightarrow$ final velocity

- If the speed of an object decreases, we say that it is decelerating, or it has a deceleration or retardation.
- If the acceleration direction is opposite to that of the velocity, the object will decelerate.

➢ **Uniform acceleration :** If a body changes it's velocity equally in equal intervals of time, then the body is said to be moving with uniform acceleration.

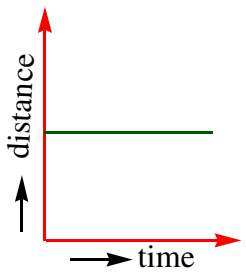
Ex : A freely falling body is an example of uniform accelerated body, because it's velocity increases approximately 10 ms^{-1} for every second.

➢ **Graphs :** A graph is a very powerful method of presenting information.

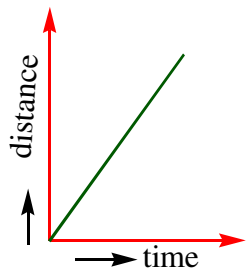
- Graphs provide a convenient method to present basic informations. It is a lot easier to get an overall idea of information.
- A graph is plotted to display the relation between two quantities.
- Plotting a graph includes (a) Choosing the axes (b) Choosing the scale (c) Marking the points (d) Joining the points.
- Generally a horizontal line from left to right is drawn to represent the independent quantity.
- A perpendicular line is drawn to represent the dependent quantity.
- These perpendicular lines will meet at a point called origin.

➢ **Distance - Time graph :** The distance - time graph of an object moving with a uniform speed is a straight line.

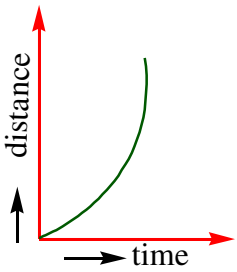
- Even though the distance - time graph is straight line the motion need not be along a straight path.
- If the distance - time graph of an object is a straight line the slope of the line gives the speed of an object.
- If an object moves with a non uniform speed, its distance - time graph is not a straight line.
- Displacement - Time graph for uniform accelerated motion is a parabola.



Rest



Uniform motion

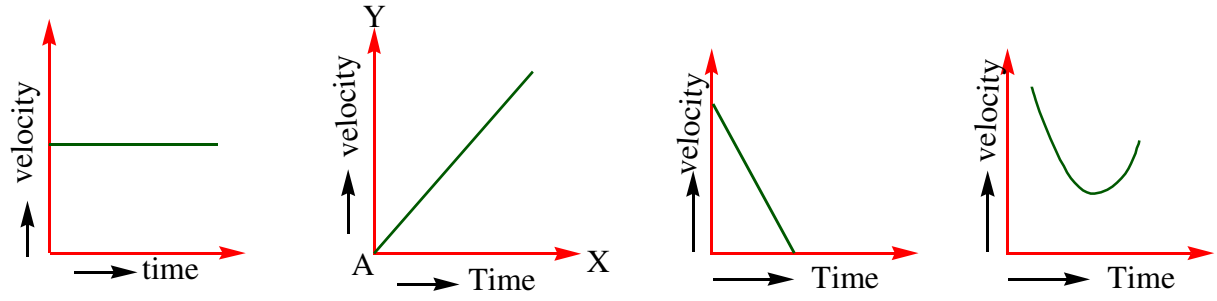


Non uniform motion

➢ **Velocity - Time graph :** If the particle moves with a constant velocity V, the velocity - time graph will be a straight line parallel to the time - axis.

- The area under the velocity - time graph of an object gives its displacement.
- The slope of the velocity - time graph gives the acceleration for an object moving along straight line.

- If the acceleration of an object moving along a straight line is not constant, the velocity -time graph is not a straight line



Uniform velocity | Uniform acceleration | Uniform retardation | Non - Uniform acceleration

➢ **Circular Motion :** A particle moving along a circular path changes its direction continuously.

- In circular motion velocity is not constant even if its speed is constant.
- For an object in circular motion direction of motion is along the direction of tangent drawn at that instant.
- Circular motion is accelerated motion.
- Time taken by the particle to complete one revolution along a circular path of radius is called time period.

➢ **Equations of Motion :** When an object moves along a straight line with uniform acceleration. Then the equations relating velocity (u, v) covered in a certain time interval (t) are

- $v = u + at$
- $s = ut + \frac{1}{2}at^2$
- $v^2 - u^2 = 2as$

ANALYSE AND APPLY

1. Displacement is a _____ quantity
2. Slope of _____ graph gives velocity
3. If the acceleration direction is opposite to that of velocity, then velocity is _____.
4.

	Column - I		Column - II
i)	Distance	p)	Scalar
ii)	Velocity	q)	Vector
iii)	Acceleration	r)	m
iv)	Displacement	s)	m/s
v)	Speed	t)	m/s^2

5. Circular motion is accelerated motion (T/F)

6. The average speed of a body is always equal to instantaneous speed (T/F)

7. A body can have non-zero speed with zero velocity (T/F)

8. Distance - time graph for uniform motion.

9. Velocity - time graph for uniform velocity.

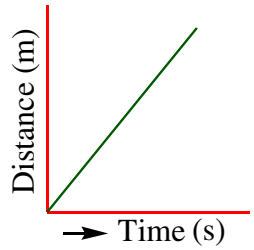
10. Distance - time graph for non-uniform motion.

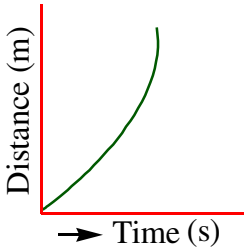
OBJECTIVE EXERCISE

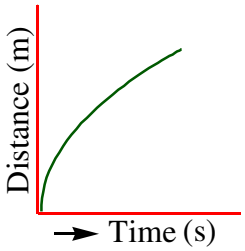
Multiple choice questions :

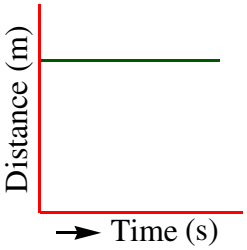
1. If the displacement of an object is proportional to square of time, then the object moves with
   a) Uniform acceleration b) Decreasing acceleration [ ]
   c) Increasing acceleration d) Uniform velocity

2. Which of the following figure represents uniform motion of a moving object correctly [ ]

a) 

b) 

c) 

d) 

3. Slope of a velocity - time graph gives [ ]
a) The distance b) The displacement c) The acceleration d) The speed

4. Suppose a boy is enjoying a ride on a merry-go-round which is moving with a constant speed of 10 ms^{-1}. It implies that the boy is [ ]
a) Moving with no acceleration b) At rest
c) In accelerated motion d) Moving with uniform velocity

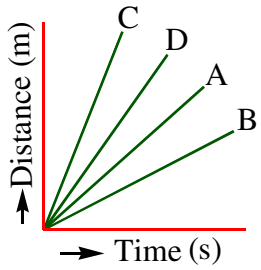
5. Four cars A,B,C are moving an a levelled road. Their distance versus time graphs are shown in Figure. Choose the correct statement. [ ]

a) Car A is faster than car D

b) Car B is the slowest

c) Car D is faster than car C

d) Car C is the slowest.



6. A bus decreases its speed from 80 kmph, to 60 kmph, in 5 s. Find the acceleration of the bus [ ]
a) a = – 2.11 ms^{-2} b) a = +2.11 ms^{-2} c) a = – 1.11 ms^{-2} d) a = + 1.11 ms^{-2}

7. A particle moves over three quarters of a circle of radius r. What is the displacement [ ]
a) $\sqrt{2}\,r$ b) $\sqrt{2r}$ c) $3\sqrt{r}$ d) $\sqrt{3}\,r$

8. A motorcyclist drives A to B with a uniform speed of 30 kmph and returns back with a speed of 20 kmph. Find its average speed. [ ]
a) 20 kmph b) 24 kmph c) 42 kmph

9. A body thrown in the vertically upwards direction rises upto a height 'h' and comes back to the position of start. [ ]
i) The total distance travelled by the body ; and
ii) The displacement of the body
a) 4h, zero b) 2h, zero c) zero, 4h d) zero, 2h

10. When a graph of one quantity versus another results in a straight line, the quantities are [ ]
a) Both constant b) Equal c) directly proportional d) Inversely proportional

11. If a particle covers equal distances in equal time intervals, it is said to [ ]
a) Be at rest b) Move with uniform speed
c) Move with a uniform velocity d) The particle moves along a straight line.

12. A quantity has a value of – 6.0 m/s. It may be the [ ]
a) Speed of a particle b) Velocity of a particle
c) Acceleration of particle d) Position of a particle

13. The velocity - time graph of a particle is not a straight line. Its acceleration is [ ]
a) Zero b) Constant c) Negative d) Variable

14. Which of the following is correct [ ]
a) $s = ut + \frac{1}{2}t^2$ b) $v^2 - u^2 = 2a$ c) $v = u + at$ d) $s_n = u + \left(n - \frac{1}{2}\right)$

15. Whenever an object moves with a constant speed, its speed - time graph is a [ ]
a) Parabola, parallel to the time axis b) Straight line, perpendicular to the time axis
c) Straight line, parallel to the time axis d) Parabola, perpendicular to the time axis

16. Convert 15m/s into km/h [ ]
a) 24 km/h b) 30 km/h c) 50 km/h d) 54 km/h

17. The area under a speed - time graph is represented by the unit [ ]
a) m b) m^2 c) m^3 d) m^{-1}

18. A bus decreases its speed from 80 m/s to 40 m/s is 5 s. Then acceleration of the bus is [ ]
a) 8 ms^{-2} b) – 8 ms^{-2} c) 10 ms^{-2} d) –10 ms^{-2}

19. A racing car has a uniform acceleration of 4 ms^{-2}. Then distance will it cover in 10 s after start is
a) 100 m b) 200 m c) 300 m d) 400 m [ ]

20. If 's' is displacement and 'd' is distance between two points in a straight line, then the correct relation is [ ]
a) s = d b) s > d c) d > s d) none

21. Area under a v - t graph represents a physical quantity which has the unit [ ]
a) m^2 b) m c) m^3 d) ms^{-1}

Assertion & Reason Tpye Questions :

a) Both A and R are correct and R is the correct explanation of A
b) Both A and R are correct but R is not the correct explanation of A
c) A is correct, R is incorrect d) A is incorrect, R is correct

22. **Assertion (A)** : A body may be moving with uniform speed and non uniform acceleration
Reason (R) : A body may have uniform velocity and non-zero acceleration. [ ]

23. **Assertion (A)** : The displacement - time graph of a body moving with uniform acceleration is not a straight line. [ ]
Reason (R) : The displacement is proportional to time for uniform accelerated motion.

24. **Assertion (A)** : A body may be accelerated even when it is moving at uniform speed. [ ]
Reason (R) : When direction of motion of the body is changing then body may have acceleration.

25. **Assertion (A)** : The position - time graph of a body moving uniformly in a straight line parallel to postition axis. [ ]
Reason (R) : The position - time graph in a uniform motion gives the velocity of an object.

OLYMPIAD CORNER

1. Whenever an object moves with a constant speed, its distance - time graph is a [ ]
a) Parabola, parallel to the time axis b) straight line, perpendicular to the time axis
c) Straight line, parallel to the time axis d) Straight line passing through origin.

2. The velocity of a particle is zero at t = 0 [ ]
a) The acceleration at t = 0 may be zero
b) If the acceleration is zero from t = 0 to t = 10s, the speed is also zero in this interval
c) If the speed is zero from t = 0 to t = 10s the acceleration is also zero in this interval
d) All the above

3. A car is starting from rest, travelled a distance 'S' and gained a velocity v_0. What is the distance travelled by the car when it continues with same acceleration and velocity gets doubles ? [ ]
a) 4S b) 2S c) 3S d) S

4. A particle is moving in a straight line and it is gradually slowing down. Then what is the angle between velocity and acceleration ? [ ]
a) 0^c b) $\frac{\pi^c}{2}$ c) $\frac{\pi^c}{4}$ d) π^c

5. A police van moving on a highway with a speed of 30 km/h fires a bullet at a thief's car speeding away in the same direction with a speed of 192 km/h. If the muzzle speed of the bullet is 150 m/s^{-1}. with what speed does the bullet hit the thief's car ? (Note obtain that speed which is relevant for damaging the thief's car). [ ]
a) 105 m/s b) 100 m/s c) 95 m/s d) 110 m/s

6. A car accelerates from rest at a constant rate 'α' for same time after which it decelerate's at a constant rate 'β' to come to rest if total time elapsed is 't' second s then the maximum velocity reached is
a) $V_{max} = \left(\frac{\alpha\beta}{\alpha+\beta}\right)t$ b) $V_{max} = \left(\frac{\alpha\beta}{\alpha+\beta}\right)\frac{1}{t}$ [ ]
c) $V_{max} = \frac{(\alpha+\beta)t}{\alpha\beta}$ d) $V_{max} = \frac{\alpha+\beta}{\alpha\beta t}$

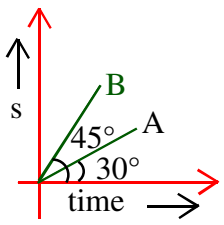
7. Person 'x' moves from point A to point B with uniform speed 30 kmph, B to A with 60 kmph. then average speed is _____ $\times 10^1$ m/s. [ ]
a) 10 / 9 b) 20 / 9 c) 50 / 9 d) 40 / 9

8. A particle moving with constant acceleration of 2 m/s^2 due west has an initial velocity of 9 m/s^2 due east. Then the distance covered in the fifth second of its motion will be [ ]
a) $\frac{1}{4}$ m b) 1 m c) $\frac{3}{4}$ m d) $\frac{1}{2}$ m

9. Average velocity of a particle moving in a straight line with constant acceleration 'a' and initial velocity 'u' in 't' seconds is [ ]
a) $u + \frac{at}{2}$ b) u + at c) $\frac{at}{2}$ d) $\frac{u+at}{2}$

10. A racing car has an uniform acceleration of 2 m/s^2 what distance will it cover in 5 s after start?
a) 25 m b) 35 m c) 20 m d) 15 m [ ]

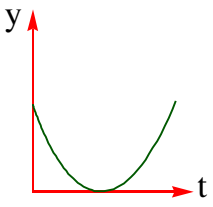
11. For a body displacement - time graph is given in figure. The ratio of the velocities of A and B is [ ]
a) $\sqrt{3}$: 1
b) 1 : 1
c) 1 : 2
d) 1 : $\sqrt{3}$

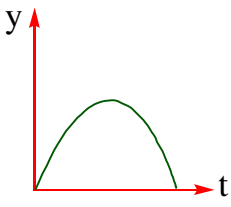


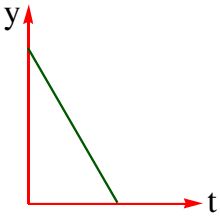
12. Two childern start at one end of a street (the origin), run to the other end , then head back.On the way back Sita is ahead Gita. Which statement is correct about the displacements from the origin at that moment? [ ]
a) Gita has run a greater distance, but her displacement is less than Sita's
b) Gita has run a greater distance and her displacement is greater than Sita's
c) Sita has run a greater distance, but her displacement is less than Gita's
d) Sita has run a greater distance and her displacement is greater than Gita's

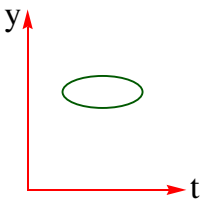
13. Ball A was dropped from the top of a tall building. At the same instant and from the same height ball B was thrown straight downward. Neglecting the effects of air friction, compare their accelerations while they were falling. [ ]
a) Their accelerations are equal
b) Ball A has the greater acceleration
c) Ball B has the greater acceleration
d) Initially A has greater acceleration and after some time B has greater acceleration.

14. Which of the following speed- time graphs is not possible? [ ]

a) 

b) 

c) 

d) 

15. A bullet is fired on to a wall with a velocity of 50 m/s. If the bullet at the depth of 10 cm inside the wall, find the retardation produced by the wall [ ]
a) $-1250\ ms^{-2}$ b) $12500\ ms^{-2}$ c) $-2050\ ms^{-2}$ d) $3250\ ms^{-2}$

16. A particle experiences constant acceleration for 20 s after starting from rest. If it travels a distance s_1 in the first 10 s and distance s_2 in the next 10s then [ ]
a) $s_2 = s_1$ b) $s_2 = 2s_1$ c) $s_2 = 3s_1$ d) $s_2 = 4s_1$

17. A train is moving at a speed of 40 km/h at 10.00 a.m and at 50 km/h at 10.15 a.m. Assuming that the train moves along a straight track and the acceleration is constant, find out the value of the acceleration.
a) $30\ km/h^2$ b) $40\ km/h^2$ c) $35\ km/h^2$ d) $25\ km/h^2$ [ ]

18. A car covers 30 km is 30 minutes and the next 30 km is 40 minutes. Calculate the average speed for the entire journey. [ ]
a) 51.4 km/h b) 52.4 km/h c) 25.4 km/h d) 21.4 km/h

19. A particle with a velocity of 2m/s at t = 0 moves along a straight line with a constant acceleration of $0.2\ m/s^2$. Find the displacement of the particle in 10 s. [ ]
a) 40 m b) 30 m c) 50 m d) 35 m

20. A bus starting from rest moves with a uniform acceleration by $0.1 ms^{-2}$ for 2 minutes then the speed acquired and distance travelled. [ ]
a) 12 m, $720\ ms^{-1}$ b) $72 ms^{-1}$, 120 m c) 12 ms^{-1}, 720 m d) 720 ms^{-1}, 12 m

2 FORCE AND LAWS OF MOTION

WISE UP

- **Velocity :** The velocity of an object is a quantity that gives the speed of the object as well as its direction.
  - **Velocity** $= \frac{\textbf{Displacement}}{\textbf{Time}}$.
  - Velocity is a vector
- **Acceleration :** When the motion is non-uniform, the object is said to have an 'acceleration'.
  - Acceleration is the change in velocity per unit time.
  - Acceleration is a vector quantity. SI unit ms^{-2}.
  - $a = \frac{v-u}{t}$ $\quad u \rightarrow$ initial velocity, $v \rightarrow$ final velocity
- To accelerate a body, a neccessary push or pull is required.
- A push or pull on a body is called force.
- A force cannot be seen. A force can be judged only by the effects.
- Effect of force depend not only on the magnitude of force but also depends on the area on which it is applied.
- An interaction of one object results in a force between the two objects.
- The strength of force is usually expressed by its magnitude.
- Force has both magnitude and direction. If the magnitude or the direction changes the effect of force can change.
- **Effects of force**
  - A force can change the state of motion.
  - A changes is either the speed of object, or its direction of motion, or both is described as a changes in its state of motion.
  - Force can change the shape of object.
- There are various types of forces such as muscular, magnetic, electrostatic, gravitational, buoyant and frictional.
- **Contact force :** It is a force applied to a body by another body that is in contact.

  Ex : Muscular force, Tension, Friction, etc.,
  - The force resulting due to the action of muscles is known as the muscular force.
  - Friction force always acts on all the moving parts and its direction is always opposite to the direction of motion.

➢ **Non contact force :** It is a force which acts on object without coming actual contact.

Ex : Gravitational force, magnetic force, electric force, etc.,

- The force which is responsible to the fall of objects towards the earth is called **Gravitational force.**
- Every object in universe whether small or large, exerts a force on every other object. This force is called Gravitational force.
- The force exerted by the charged body on another charged body (or) uncharged body is called **Electrostatic force**.

➢ **Balanced and unbalanced forces :**

- If the resultant of all forces acting on a body is zero, the forces are called balanced forces.
- If the resultant of all forces acting on a body is not zero, the forces are called unbalanced forces.

NCERT TEXTUAL QUESTIONS

1. Which of the following has more inertia : (Understanding)

a) A rubber ball and stone of the same size ?

b) A bicycle and a train ?

c) A five rupee coin and a one rupee coin ?

A. a) If we take a stone and a rubber ball of the same size then mass of the stone will be more. But mass is a measure of inertia hence inertia of stone is more.

b) As mass of train is more than of bicycle hence inertia of train is more than inertia of bicycle.

c) Mass of a five rupee coin is more than the mass of a one rupee coin. Hence, inertia of five rupee coin is more than the inertia of one rupee coin.

2. In the following example, try to identify the number of times the velocity of the ball changes. "A football player kicks a football to another player of his team who kicks the football towards the goal. The goalkeeper of the opposite team collects the football and kicks it towards a player of his own team" also identify the agent supplying the force in each case. (Understanding)

A. Velocity of football changes four times. First and second change is by player when they kick. Third and fourth change comes from goal keeper who picks the football and then kicks it.

3. Explain why some of the leaves may get detached from a tree if we vigorously shake its branches. (Understanding)

A. When a branch of tree is shaked vigorously then some leaves get detached on account of inertia of rest of the leaves. When branch comes in motion, leaves tend to remain in their position of rest, hence some leaves get detached.

4. Why do you fall in the forward direction when a moving bus brakes to a stop and fall backwards when it accelerates from rest ? (Understanding)

A. When brakes are applied to stop a bus, lower part of the body comes to rest with bus where as upper part of the body remains in motion resulting in forward fall. Similarly, when a bus starts from rest, initially lower part of the body comes in motion resulting in backward fall.

NCERT TEXTUAL EXERCISE QUESTIONS

1. An object experiences a net zero external unbalanced force. Is it possible for the object to be travelling with a non-zero velocity ? If yes, state the conditions that must be placed on the magnitude and direction of the velocity. (Understanding)

A. Yes, an object may travel with a non-zero velocity even when the net external force on it is zero. A rain drop falls down with a constant velocity. The weight of the drop is balanced by the upthrust and the viscosity of air. The net force on the drop is zero.

2. When a carpet is beaten with a stick, dust comes out of it. Explain. (Understanding)

A. It is due to the inertia of rest. When the carpet is beaten with a stick, the carpet moves forward. The dust particles stay behind (due to inertia of rest). They come out and fall down. In this way, dust gets removed.

3. Why is it advised to tie any luggage kept on the roof of a bus with a rope ? (Understanding)

A. As the bus moves ahead with acceleration, the luggage on the roof should also moves along with it. Due to inertia of rest, the luggage tends to remain behind. It slides on the roof in the backward (rear) direction. If not tied with a rope, the luggage may fall behind the bus on the road.

4. A batsman hits a cricket ball which then rolls on a level ground. After covering a short distance, the ball comes to rest. The ball slows down to stop because (Creating)

a) The batsman did not hit the ball hard enough.

b) Velocity is proportional to the force exerted on the ball.

c) There is a force on the ball opposing the motion.

d) There is no unbalanced force on the ball, so the ball would want to come to rest.

A. c) There is a force on the ball opposing the motion.

5. A truck starts from rest and rolls down a hill with a constant acceleration. It travels a distance of 400 m in 20 s. Find its acceleration. Find the force acting on it if its mass is 7 tonnes (Hint : 1 tonne = 1000 kg). (Applying)

A. Mass of truck (m) = 7 metric ton = 7000 kg

Initial velocity of the truck (u) = 0 ms^{-1}

Distance covered (s) = 400 m

Time taken (t) = 20 s

Acceleration (a) = ?

$$S = ut + \frac{1}{2}at^2 \qquad (\because\ u = 0\ ms^{-1})$$

$$S = \frac{1}{2}at^2$$

$$a = \frac{2S}{t^2} = \frac{2\times 400}{20\times 20}$$

$$\boxed{a = 2\,m/s^2}$$

Force F = ma

= 7000 kg × 2 ms^{-2} = 14000 N

6. A stone of 1kg is thrown with a velocity of 20 ms^{-1} across the frozen surface of a lake and comes to rest after travelling a distance of 50 m. What is the force of friction between the stone and the ice ? (Applying)

A. Mass of the stone (M) = 1kg

Initial velocity of the stone, u = 20 m/s

Final velocity of the stone, v = 0 m/s

Distance travelled, s = 50 m

Force of friction F = ?

From $v^2 - u^2 = 2aS$,

$$a = \frac{v^2 - u^2}{2S} = \frac{0 - (20)^2}{2\times 50} = -4\ ms^{-2}$$

F = ma

= (1) × (–4) kg ms^{-2} = – 4 kg ms^{-2}

$$\boxed{F = -4N}$$

–ve sign means that the force is in direction opposite to the motion.

7. A 8000 kg engine pulls a train of 5 wagons, each of 2000 kg, along a horizontal track. If the engine exerts a force of 40000 N and the track offers a friction force of 5000 N, then calculate:
a) The net accelerating force b) The acceleration of the train (Applying)

A. Mass of train (M) = 5 × 2000 kg = 10,000 kg

Force of engine on the train F_1 = 40,000 N

Force of friction, F_2 = 5,000 N

a) Net accelerating force F = ?

$F = F_1 - F_2$

F = (40,000 – 5,000) N

$$\boxed{F = 35,000N}$$

b) Acceleration of the train $= \left(\frac{force}{mass}\right) \Rightarrow a = \left(\frac{35,000}{18,000}\right) \Rightarrow$ a = 1.95 N/kg = 1.95 ms^{-2}

8. An automobile vehicle has a mass of 1500 kg. What must be the force between the vehicle and road if the vehicle is to be stopped with a negative acceleration of 1.7 ms^{-2} ? (Applying)

A. Mass of automobile, m = 1500 kg
Acceleration of automobile, a = – 1.7 m/s^2
Force between vehicle and road F = ?

$F = ma = 1500 \times (-1.7)$

$$\boxed{F = -2,550 kgm/s^2}$$

–ve sign indicates that the force acts in a direction opposite to the motion of vehicle.

9. What is the momentum of an object of mass m, moving with a velocity *v* ?
a) $(mv)^2$ b) mv^2 c) ½ mv^2 d) mv
(Analyzing and Evaluating)

A. d) Momentum, p = mv

10. Using a horizontal force of 200 N, we intend to move a wooden cabinet across a floor at a constant velocity. What is the frictional force that will be exerted on the cabinet ? (Applying)

A. Horizontal force applied, F_a = 200 N
Acceleration of cabinet a = 0 m/s^2
Force due to friction F_f = ?
object moves with constant velocity means
Applied force = Frictional force

$F_f = F_a = 200$ N $\quad [\because F_a - F_f = F = 0]$

11. According to newton's third law of motion when we push on an object, the object pushes back on us with an equal and opposite force. If the object is a massive truck parked along the roadside, it will probably not move. A student justifies this by answering that the two opposite and equal forces cancel each other. Comment on this logic and explain why the truck does not move. (Understanding)

A. As we push the truck with a small force and the truck does not move, an equal amount of force of friction, on the truck opposes its motion. As we increases the applied force, frictional force also increases. (It has self - adjusting nature) and becomes equal and opposite to the applied force. Till a stage of limiting friction is reached, the truck does not move.

12. A hockey ball of mass 200 g travelling at 10 ms^{-1} is struck by a hockey stick so as to return it along its original path with a velocity at 5 ms^{-1}. Calculate the change of momentum occured in the motion of the hockey ball by the force applied by the hockey stick. (Applying)

A. Mass of the ball, m = 200 g = 0.2 kg
Initial velocity of the ball, v_1 = 10 m/s
Final velocity of the ball v_2 = –5 m/s
Change in momentum, Δp = ?

$\Delta p = p_2 - p_1 = m v_2 - m v_1$
$= m (v_2 - v_1) = 0.2 \times (-5 - 10)$

$$\boxed{\Delta p = -3 \ kgm/s}$$

–ve sign means that final motion is in a direction opposite to the initial motion.

13. A bullet of mass 10 g travelling horizontally with a velocity of 150 ms^{-1} strikes a stationary wooden block and comes to rest in 0.03 s. Calculate the distance of penetration of the bullet into the block. Also calculate the magnitude of the force exerted by the wooden block on the bullet. (Applying)

A. Mass of bullet, m = 10 g = 0.01 kg
Initial velocity of bullet, u = 150 m/s
Final velocity of the bullet, v = 0 m/s
Time taken t = 0.03 s
Force exerted by the block on the bullet F = ?

$$F = \frac{m(v-u)}{t} = \frac{0.01\times(0-150)}{0.03} = -50\ kgms^{-2}$$

$$\text{Acceleration} = \frac{force}{mass}$$

$$= a = \frac{-50}{0.01} = -5000\ m/s^2$$

Distance of penetration S = ?

$$S = \frac{v^2-u^2}{2a} = \frac{0^2-(+150)^2}{2\times(-5000)} \Rightarrow S = \frac{150\times150}{2\times5000} = 2.25\,m$$

14. An object of mass 1 kg travelling in a straight line with a velocity of 10 ms^{-1} collides with, and sticks, to, a stationary wooden block of mass 5 kg. Then they both move off together in the same straight line. Calculate the total momentum just before the impact and just after the impact. Also, calculate the velocity of the combined object. (Applying)

A. Mass of first object, m_1 = 1 kg
Velocity of first object, u_1 = 10 m/s
Mass of wooden block, m_2 = 5 kg
Velocity of wooden block, u_2 = 0 m/s
According to law of conservation of momentum,
$(m_1 + m_2) \times v = m_1u_1 + m_2u_2$
Velocity of combined object is, v = ?

$$v = \frac{m_1u_1+m_2u_2}{m_1+m_2} = \frac{1\times10+5\times0}{1+5} = \frac{10}{6} = \frac{5}{3}$$

v = 1.67 m/s
Total momentum before impact,
$p_i = m_1u_1 + m_2u_2 = 1 \times 10 + 5 \times 0$
p_i = 10 kgm/s
Total momentum after impact

$$p_f = (m_1 + m_2) \times v \Rightarrow p_f = (1+5)\times\frac{5}{3} = 6\times\frac{5}{3}$$

p_f = 10 kgm/s

15. An object of mass 100 kg is accelerating uniformly from a velocity of 5 ms^{-1} to 8 ms^{-1} in 6 s. Calculate the initial and final momentum of the object. Also, find the magnitude of the force exerted on the object. (Applying)

A. Mass of object m = 100 kg

Initial velocity of object u = 5 m/s

Final velocity of object v = 8 m/s

Time taken t = 6 s

Initial momentum, $p_i = mu = 100 \times 5 = 500$ kg ms^{-1}

Final momentum $p_f = 100 \times 8 = 800$ $kgms^{-1}$

Magnitude of force $F = \frac{m(v-u)}{t} = \frac{100 \times (8-5)}{6} = \frac{100(3)}{6} = 50$ $kgms^{-2}$

F = 50 N

16. Akhtar, Kiran and Rahul were riding in a motorcar that was moving with a high velocity on an expressway when an insect hit the windshield and got stuck on the wind screen. Akhtar and Kiran started pondering over the situation. Kiran suggested that the insect suffered a greater change in momentum as compared to the change in momentum of the motorcar (because the change in the velocity of the insect was much more than that of motorcar), Akhtar said that since the motorcar was moving with a larger velocity, it exerted a larger force on the insect. And as a result the insect died, Rahul while putting an entirely new explanation said that both the motorcar and the insect experienced the same force and a change in their momentum. Comment on these suggestions. (Analyzing and Evaluating)

A. Rahul was correct According to law of conservation of linear momentum, during collision between two bodies of a system total momentum remains same. The colliding bodies suffer an equal and opposite change of momentum both experience equal and opposite (action and reaction) forces due to same duration of collision

17. How much momentum will a dumbbell of mass 10 kg transfer to the floor if it falls from a height of 80 cm ? Take its downward acceleration to be 10 ms^{-2}. (Applying)

A. Mass of dumbbell, m = 10 kg

Height fallen, s = h = 0.8 m

Acceleration, a = 10 m/s^2

Initial velocity, u = 0 m/s

Velocity acquired v = ?

From equation $v^2 - u^2 = 2aS$

$v^2 = 2gh$

$= 2 \times 10 \times 0.8$

v = 4 m/s

Momentum acquired, p = mv = 10 × 4 m/s

p = 40 kg ms^{-1}

TEXT BOOK SOLVED PROBLEMS

1. A constant force acts on an object of mass 5 kg for a duration of 2s. It increases the object's velocity from 3 ms^{-1} to 7 ms^{-1}. Find the magnitude of the applied force. Now, if the force was applied for a duration of 5 s, what would be the final velocity of the object ? (Applying)

A. We have been given that u = 3 ms^{-1} and v = 7 ms^{-1}, t = 2 s and m= 5 kg.

We have, $F = \frac{m(v-u)}{t}$

Substitution of values in this relation gives

F = 5 kg (7 ms^{-1} – 3 ms^{-1}) / 2 s = 10 N.

Now, if this force is applied for a duration of 5 s (t = 5s), then the final velocity can be calculate by

$$v = u + \frac{Ft}{m}$$

On substituting the values of u, F, m and t, we get the final velocity, v = 13 ms^{-1}.

2. Which would require a greater force, accelerating a 2 kg mass at 5 ms^{-2} or a 4 kg mass at 2ms^{-2} (Applying)

A. We have F = ma. Here we have m_1 = 2 kg; a_1 = 5 ms^{-2} and m_2 = 4 kg; a_2 = 2 ms^{-2}. Thus,

$F_1 = m_1a_1$ = 2 kg × 5 ms^{-2} = 10 N

$F_2 = m_2a_2$ = 4 kg × 2 ms^{-2} = 8 N

$\Rightarrow F_1 > F_2$.

Thus, accelerating a 2 kg mass at 5 ms^{-2} would require a greater force.

3. A motorcar is moving with a velocity of 108 km/h and it takes 4 s to stop after the brakes are applied. Calculate the force exerted by the brakes on the motorcar if its mass along with the passengers is 1000 kg. (Applying)

A. The initial velocity of the motorcar u = 108 km/h

= 108 × 1000 m / (60 × 60s) = 30 ms^{-1}

and the final velocity of the motorcar V = 0 ms^{-1}.

The total mass of the motorcar along with its passengers = 1000 kg

The time taken to stop the motorcar (t) = 4s.

The magnitude of the force (F) applied by the brakes $= m\frac{(v-u)}{t}$

On substituting the values, we get $F = 1000\,kg \times \frac{(0-30)ms^{-1}}{4s}$ = –7500 kg ms^{-2} or – 7500 N.

The negative sign tells us that the force exerted by the brakes is opposite to the direction of motion of the motorcar.

4. A force of 5 N gives a mass m_1, an acceleration of $10ms^{-2}$ and a mass m_2, an acceleration of $20ms^{-2}$. What acceleration would it give if both the masses were tied together ? (Applying)

A. We have $m_1 = \frac{F}{a_1}$, and $m_2 = \frac{F}{a_2}$,

$a_1 = 10\ ms^{-2}$; $a_2 = 20\ ms^{-2}$ and F = 5 N.

$$\therefore m_1 = \frac{5N}{10\,ms^{-2}} = 0.50\ kg,$$

$$m_2 = \frac{5N}{20\,ms^{-2}} = 0.25\ kg$$

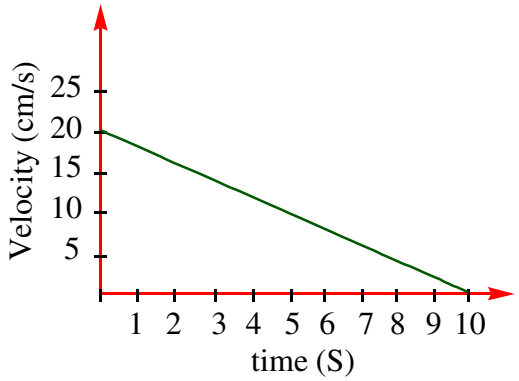
If the two masses were tied together, the total mass, m would be

m = 0.50 kg + 0.25 kg = 0.75 kg.

The acceleration, a produced in the combined mass by the 5 N force would be,

$$a = \frac{F}{m} = \frac{5N}{0.75\,kg} = 6.67\,ms^{-2}$$

5. The velocity-time graph of a ball of mass 20 g moving along a straight line on a long table is given in figure. (Applying)



How much force does the table exert on the ball to bring it to rest ?

A. The initial velocity of the ball is 20 cms^{-1}. Due to the frictional force exerted by the table, the velocity of the ball decreases down to zero in 10 s. Thus, u = 20 cms^{-1}, v = 0 cms^{-1} and t = 10 s.

Since the velocity - time graph is a straight line, it is clear that the ball moves with a constant acceleration.

The acceleration a is

$$a = \frac{v-u}{t} = (0\ cms^{-1} - 20\ cms^{-1}) / 10\ s$$

$= -2\ cms^{-2} = -0.02\ ms^{-2}$.

The force exerted on the ball F is, F = ma = (20 / 1000) kg × ($-0.02\ ms^{-2}$) = –0.0004 N.

The negative sign implies that the frictional force exerted by the table is opposite to the direction of motion of the ball.

NCERT ADDITIONAL EXERCISES

1. The following is the distance-time table of an object in motion: (Applying)

Time in seconds	Distance in metres
0	0
1	1
2	8
3	27
4	64
5	125
6	216
7	343

a) What conclusion can you draw about the acceleration? Is it constant, increasing, decreasing, or zero ?

b) What do you infer about the forces acting on the object ?

A. a) It we carefully observe the distance-time table given above, we find that $S \propto t^3$

we know that

For motion with uniform velocity

$$S = ut + \frac{1}{2}at^2 \quad (\because \text{ velocity remains constant, so acceleration zero})$$

$$S = ut$$

$$S \propto t$$

For motion with uniform acceleration, (i.e uniformly increasing velocity) when the body starts from rest.

$$S = ut + \frac{1}{2}at^2$$

$$S = \frac{1}{2}at^2 \quad (\because u = 0)$$

$$S \propto t^2$$

Also in the present case $S \propto t^3$

$$t^3 = \frac{1}{2}at^2$$

$$\boxed{a \propto t}$$

Thus we conclude that, the acceleration is increasing uniformly with time.

b) We know that, the acceleration produced in a body of given mass is directly proportional to the force applied on it.

So acting force,

$F \propto a$, the force also increases uniformly with time.

2. Two persons manage to push a motorcar of mass 1200 kg at a uniform velocity along a level road. The same motorcar can be pushed by three persons to produce an acceleration of 0.2 ms^{-2}. With what force does each person push the motorcar ? (Assume that all persons push the motorcar with the same muscular effort). (Applying)

A. Let each person exert a force of x newton. In second case, extra third person produce an acceleration.

Now force exerted by third preson in second case.

F = x newton

Mass of motorcar, m = 1200 kg

Acceleration produced, a = 0.2 m/s^2

From equation F = ma

$x = 1200 \times 0.2 = 240\ kgms^{-2}$

Force exerted by each person is $\boxed{x = 240N}$

3. A hammer of mass 500 g, moving at 50 ms^{-1}, strikes a nail. The nail stops the hammer in a very short time of 0.01 s. What is the force of the nail on the hammer ? (Applying)

A. Mass of the hammer, m = 500 g = 0.5 kg

Initial velocity of the hammer, u = 50 m/s

Final velocity of the hammer, v = 0 m/s

Short time interval t = 0.01 s

Force of nail on the hammer, F = ?

From Impulse equation, F × t = m (v – u)

$$F = \frac{m(v-u)}{t} = \frac{0.5(0-50)}{0.01} = -\frac{0.5\times 50}{0.01}\times\frac{100}{100}$$

$\boxed{F = -2500\ N}$

4. A motorcar of mass 1200 kg is moving along a straight line with a uniform velocity of 90 km/h. Its velocity is slowed down to 18 km/h in 4 s by an unbalanced external force. Calculate the acceleration and change in momentum. Also calculate the magnitude of the force required. (Applying)

A. Mass of motorcar, m = 1200 kg

Initial velocity of the motor car, $u = 90\ kmph = 90\times\frac{5}{18} = 25\ ms^{-1}$

Final velocity of motorcar,

$v = 18\ kmph = 18\times\frac{5}{18}\ m/s = 5ms^{-1}$

Time taken, t = 4 s

Acceleration, $a = \frac{v-u}{t} = \frac{5-25}{4} = -\frac{20}{4}$

$$\boxed{a = -5\ ms^{-2}}$$

Negative sign due to retardation

Change in momentum $\Delta p = p_2 - p_1 = m\ (v - u) = 1200 \times (5 - 25) = 1200 \times (-20)$

$$\boxed{\Delta p = -24{,}000\ kgms^{-1}}$$

Magnitude of force = $\frac{change\ in\ momentum}{time\ taken} = \frac{24{,}000}{4} = 6{,}000N$

ADDITIONAL QUESTIONS

I. COMPETENCY - DEMONSTRATE KNOWLEDGE AND UNDERSTANDING

1. Define inertia. There are three solid balls made up of aluminium, steel and wood, of same shape and volume. Which of them would have highest inertia? Why?

A. The natural tendency of objects to resist a change in their state of rest or of uniform motion is called inertia.

We know that $d = \frac{m}{V}$, all are having same volume (V) so density (d) is directly proportional to mass.

Steel has more density so it is more massive steel has highest inertia.

2. Give examples to the property of inertia of rest.

A. i) A bus initially at rest suddenly moves forward direction, the passenger in the bus fall back ward direction.

ii) Shaking the branches of tree, the fruits are detached from the branch due to inertia of rest and fall down due to gravity.

3. Define momentum and write its SI unit.

A. It is the product of mass and velocity of the body. SI unit is kg ms^{-1}.

4. In the following table the mass and speed of two bodies are given. Which body has more momentum? Justify your answer.

BODY	MASS (kg)	SPEED (m/s)
A	12	10
B	4	3

A. The product of mass and speed gives momentum. So body A has greater momentum.

Momentum = mass × velocity

$p_A = mv$

$= 12\ (10) = 120$ kg m/s

$p_B = 4\ (3) = 12$ kg m/s

$p_A > p_B$

5. State newton's Second Law of motion and prove that newton's first law of motion is special case of newton's Second Law of motion ?

A. **Newton's Second Law of motion :** This law states that the rate of change of momentum of a body is directly proportional to the applied unbalanced force and the change takes place in the direction of the force".

Newton's First Law of motion is a special case of Newton's second law : We can deduce Newton's First Law of motion from Newton's Second Law. $F = ma = m\left(\frac{v-u}{t}\right)$

$$Ft = m(v-u)$$

That is, when F = 0, v = u for whatever time t is taken because $m \neq 0$. This means that the object will continue moving with uniform velocity u through out the time t. If u is zero then v will also be zero. That is the object will remains at rest. This is nothing but Newton's first law of motion. Hence first law of motion is contained in the Newton's Second Law.

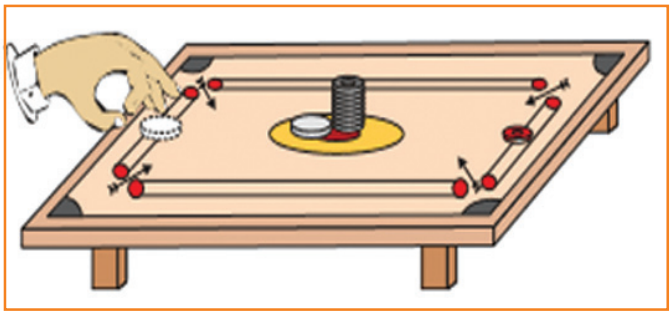
6. State Newton's third law of motion Explain how this law reasons the recoil of gun ?

A. For every action there is an equal and opposite reaction.

Recoil of the gun : Before firing, both the bullet and gun are at rest and initial momentum of the system is zero. As soon as the bullet is fired it moves forward with a large velocity. In order to conserve momentum. The gun moves backward with such a velocity that the final momentum of the system is zero.

7. Explain an activity to discribe Newton's First law of motion.

A. Every body continues to remain in its state of rest or of uniform motion unless it is compelled to change its state of rest or of uniform motion, by some external force.



Activity : Make a pile of similar carrom coins on a table, as shown in Figure. Attempt a sharp horizontal hit at the bottom of the pile using another carrom coin or the striker.

If the hit is strong enough, the bottom coin moves out quickly. Once the lowest coin is removed, the inertia of the other coins makes them 'fall' vertically on the table.

8. Chinawares are wrapped in straw paper before packing. Why?

A. The straw paper between the chinawares increases the time of experiencing the jerk during transportation. Hence, they strike against each other with less force and are less likely to be damaged.

9. Why is it necessary to bend knees while jumping from greater height ?

A. During the jump, our feet at once come to rest and for this smaller time large force acts on feet. If we bend the knees slowly, the value of time of impact increases and less force acts on feet. So we get less injury.

10. Why is the Newton's first law of motion also called "law of inertia" ?

A. According to Newton's first law of motion, a body by itself is not able to change its state of rest or of uniform motion. This property of a body is called "inertia". That is why the Newton's first law of motion is also called "law of inertia".

11. Why do we jerk wet clothes before spreading them on line ?

A. If we jerk wet clothes before spreading them on line, the cloth comes into state of motion, but before giving jerk cloth and water droplets are in state of rest after jerk also the water particles will try to remain in state of rest but cloth is in state of motion so they are separated from the cloth and due to earths pull water droplets move in downward direction.

12. It is difficult to balance our body when we accidentally step on a peel of banana. Explain why?

A. While we are keeping our foot on a peel of banana our lower part of the body shares velocity immediately but upper part of the body takes some time to share that velocity due to inertia of rest so we fall back ward direction

13. Two masses are in the ratio 1 : 4 what is the ratio of their inertia ?

A. As mass is the measure for inertia. The ratio of inertia is 1 : 4

14. Interpret force in terms of momentum.

A. Let p_1 and p_2 represent the sum of momentum of a group of objects before and after the collision, respectively. Let 't' be the time elapsed during the collision. According to Newton's second law of motion.

External force = Rate of change of momentum or $F = \frac{p_2 - p_1}{t}$

15. Using the Newton's second law obtain the unit of force and define ?

A. According to the Newton's Second Law, the rate of change of momentum is directly proportional to the applied force, so

$F \propto ma$ or F = kma

Where k is constant, the unit of force is so choosen that k is equal to one.

If m = 1, a = 1 & F = 1 then

1 = k.1.1. or k = 1

$\therefore$ F = ma

The unit force is, that force which produces a unit acceleration in a body of unit mass.

The SI unit of force is newton.

One newton is that force which produces an acceleration of $1m/s^2$ in a body of mass 1kg.

$1N = 1\ kg\ m/s^2$

16. a) Why are road accidents at high speed very much worse than accidents at low speed?

b) State the laws of motion involved in the working of a jet plane

c) Name the physical quantity whose unit is

i) $kgms^{-2}$ ii) $Nm^2\ kg^{-2}$

A. a) We know that momentum is directly proportional to velocity. From Newton's second law we know that rate of change of momentum is directly proportional to force, during impact more force exerted on each other.

b) Law of motion involved in the working of a jet plane is only Newton's third law of motion i.e., To every action there is an equal and opposite reaction

c) $kgms^{-2}$ is the unit of Force

$Nm^2\ kg^{-2}$ is the unit of universal gravitational constant

17. A large truck and a car, both moving with a velocity of magnitude v, have a head-on collision and both of them come to a halt after that. If the collision lasts for 1s :

a) Which vehicle experiences the greater force of impact ?

b) Which vehicle experience the greater change in momentum ?

c) Which vehicle experience the greater acceleration ?

d) Why is the car likely to suffer more damage than the truck ?

A. Given that mass of truck is more than mass of the car.

Change in velocity is same for both, duration of impact is same for both.

From impulse equation.

$$F \times t = m\,(v - u) \Rightarrow F = \frac{m(v-u)}{t}$$

a) From the above equation,

For some change of velocity and duration of impact

$F \propto m$

Truck experience the greater force of impact.

b) For same change of velocity.

Change in momentum α m

Truck experiences the greater change in momentum.

c) Acceleration $\frac{v-u}{t}$ is same for both.

d) Truck experiencing greater force of impact, exerts more force of reaction on the car which suffers more damage

18. If the mass of a body is double, what happens to its acceleration when acted upon by the same force?

A. From Newton's second law, F = ma

In the statement force is constant

So, ma = constant

$$\Rightarrow \quad a \propto \frac{1}{m}$$

As mass is doubled acceleration is halved.

19. When a motorcar make a sharp turn at high speed, we tend to get thrown to one side, why?

A. Due to inertia of direction we have tendency to continue to move in the same direction, so we tend to get thrown to one side

20. Give reasons for the following

a) When a bus at rest starts suddenly a standing passengers tends to fall backward

b) A cricketer lowers his hands while catching a ball

A. a) Due to inertia of rest

b) Impulse = F × t = mv – mu

Force × Time = Change in Momentum = Constant

Hence we say $F \propto \frac{1}{t}$

While moving his hands backward, the cricketer increases the time taken to stop the ball. As a result he has to apply a small force on the ball. In reaction, the ball also applies lesser force and the hands of the player are not injured

II. COMPETENCY - APPLICATION OF KNOWLEDGE/CONCEPTS

1. A ball of mass 10 g is moving with a velocity of 50 m s^{-1}. On applying a constant force on ball for 2.0 s, it acquires a velocity of 70 m s^{-1}. Calculate :

i) The initial momentum of ball.

A. Given, m = 10 g = $\frac{10}{1000}$ kg = 0.01 kg, u = 50 m s^{-1}, t = 2.0 s, v = 70 m s^{-1}.

Initial momentum of ball = mass × initial velocity

= mu

= 0.01 × 50

= 0.5 kg m s^{-1}

ii) The final momentum of ball,

A. Final momentum of the ball = mass × final velocity

= mv

= 0.01 × 70 = 0.7 kg ms^{-1}

iii) The rate of change of momentum,

A. Rate of change of momentum

$$= \frac{\text{Final momentum-Intial momentum}}{\text{Time interval}}$$

$$= \frac{(0.7-0.5)}{2.0} = 0.1 \text{ kg m } s^{-2} \text{ (or 0.1 N)}$$

iv) The acceleration of ball,

A. Acceleration a = $\frac{v-u}{t} = \frac{(70-50)}{2} = 10 ms^{-2}$

v) The magnitude of force applied.

A. Force = mass × acceleration

= ma

= 0.01 kg × 10 m s^{-2} = 0.1 N

2. For how long should a force of 100 N act on a body of mass 20 kg so that it acquires a velocity of 100 m/s?

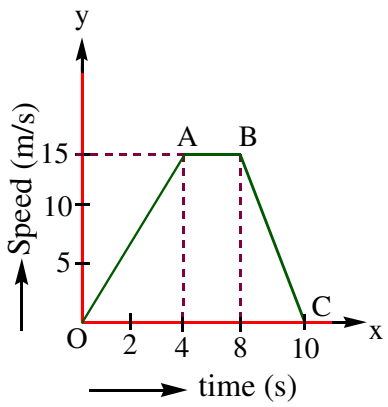
A. F = 100 N, m = 20 kg

$$a = \frac{F}{m} = \frac{100}{20} = 5 \ m/s^2$$

Now u = 0, v = 100 m/s, a = 5 m/s^2

$$t = \frac{v-u}{a} = \frac{100-0}{5} = 20 s$$

3. The speed – time graph of a car of 1000 kg mass is given below. From the graph answer the following



A. i) **Acceleration of the car :**
Slope of 'OA' curve gives acceleration

Acceleration = $\frac{15-0}{4-0} = \frac{15}{4} m/s^2$

ii) **Force on the car along 'OA' path is :**

$$F = ma = 1000 \times \frac{15}{4} = 3750 \ N$$

This is the maximum force acting on the car because acceleration is positive here

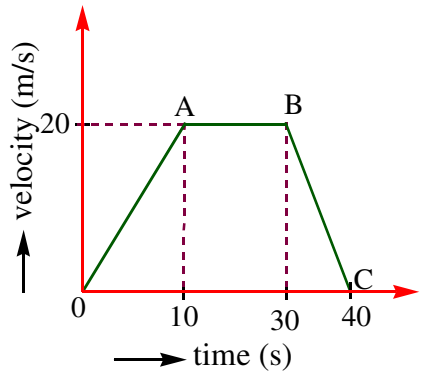
iii) **Retardation of the car is along the line BC :**

Slope of BC line gives retardation $= \frac{0-15}{10-8} = \frac{-15}{2}$

Retarding force $= 1000 \times \left(\frac{-15}{2}\right) = -500 \times 15 = -7500$ N

4. For a 2 kg mass, the v – t graph is given. Find the force experienced by the mass in OA, AB and BC.

A. Slope of 'OA' line is $= \frac{20-0}{10-0} = \frac{20}{10} = 2\,m/s^2$



Force experienced by the mass in 'OA' path

F = ma = 2 × 2 = 4 N

Slope of AB line is zero, so force is zero

Slope of 'BC' line is $= \frac{0-20}{40-30} = \frac{-20}{10} = -2\,m/s^2$

Force experienced by the mass in 'BC' path is

F = ma = (+2) × (–2) = –4 N

5. The velocity time graph of a ball of mass 20 g moving along a straight line on a level ground is given below. How much force does the ground exert on the ball to bring it to rest ?

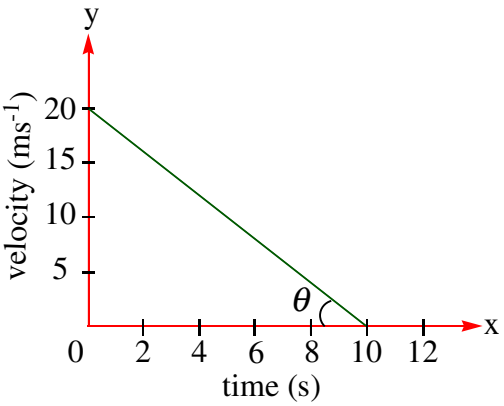
A. $Slope = \tan\theta = \frac{\Delta y}{\Delta x}$

Slope of velocity - time graph gives acceleration.

Slope $= \frac{y_2 - y_1}{x_2 - x_1} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{0-20}{10-0} = \frac{-20}{10} = -2m/s^2$

$\Rightarrow$ a = – 2 m/s^2

Force (F) = $m \times a$



$= \frac{2\cancel{0}}{100\cancel{0}} \times (-2) = \frac{-4}{100} = \frac{-1}{25} = -0.04\,N$

$\boxed{F = -0.04N}$

Negative sign indicated force is in opposite direction to the motion of ball.

6. A bullet of mass 10 g strikes a sand - bag at a speed of 10^3 m/s and gets embedded after travelling 5 cm. Calculate (i) the resistive force exerted by the sand bag (ii) the time taken by the bullet to come to rest?

A. Mass of bullet (m) = 10 g = 10^{-2} kg

Speed of bullet (v) = 10^3 m/s

Distance travelled (s) = 5 cm = 5×10^{-2} m

Work done = K.E of bullet

$$F \times s = \frac{1}{2}mv^2$$

$$F = \frac{mv^2}{2s} = \frac{10^{-2}(10^3)^2}{2\times5\times10^{-2}} = 10^5 \text{ N}$$

From $v = u + at$

$$0 = 10^3 + (\frac{-10^5}{10^{-2}}) \times t$$

$$t = \frac{10^3}{10^7} = 10^{-4} s$$

7. A force of 5 N produces an acceleration of 8 m/s² in a mass m_1 and acceleration of 24 m/s² in another mass m_2. What acceleration would the same force provided if both the masses are tied together?

A. $F = ma$, $m_1 = \frac{F}{a_1} = \frac{5}{8} kg$

$$m_2 = \frac{F}{a_2} = \frac{5}{24} kg$$

Total mass $m = m_1 + m_2 = \frac{5}{8} + \frac{5}{24} = \frac{15+5}{24} = \frac{20}{24} kg$

Net acceleration $a = \frac{F}{m} = \frac{5}{\frac{20}{24}} = \frac{24}{20} \times 5 = 6 \, m/s^2$.

8. A machine gun can fire 50 g bullets with a velocity of 150 m/s. A 60 kg stone is moving towards the machine gun velocity of 10 m/s. How many bullets must be fired from the gun to just stop the stone in its track ?

A. Let us consider 'n' bullets are required to stop a moving stone

Mass of bullet, m_b = 50 g = $\frac{50}{1000} kg = \frac{1}{20} kg$

Initial velocity of bullet, v_1 = 150 m/s

Mass of stone is, $m_s = 60$ kg

Initial velocity of stone is $v_1^{|} = 10$ m/s

Change in momentum of 'n' bullets should be equal to change in momentum stone.

$$nm_b (v_2 - v_1) = m_s \left(v_2^{|} - v_1^{|}\right)$$

$$n\frac{50}{1000}(0-150) = 60(0-10)$$

$$n\frac{1}{20}(-150) = -600$$

$$n = \frac{600\times 2}{150} = 8$$

III. COMPETENCY - FORMULATE, ANALYZE, EVALUATE AND CREATE

1. It is easier to stop a tennis ball than a cricket ball moving with the same speed. Why ?

A. This is because tennis ball is lighter than the cricket ball. It has a smaller momentum and hence smaller force is required to stop the tennis ball

2. A ball is thrown vertically upwards. What is its momentum at the highest point ?

A. At the highest point, velocity v = 0 m/s

$\therefore$ p = m(0) as p = mv

p = zero

3. A kite is skilfully held stationary in the sky. Give the magnitude and the direction of the force acting on it ?

A. As kite is held stationary, no net force acts on it. The force exerted by air on the kite is balanced by tension produced in the string.

4. A brick can be pushed gently on the smooth floor by applying force with our foot. But if we kick the brick, the foot is hurt why ?

A. When the brick is kicked, the time for which force is impressed is short and hence rate of change of momentum of the brick is large. The brick in turn, due to reaction applies large force on the foot. This force may hurt our foot.

5. What happens to a stone tied to the end of a string and whirled in a circle if the string suddenly breaks ?

A. The stone flies off tangentially along a straight line due to inertia of direction.

6. Two similar vehicles are moving with same velocity on the road, such that one of them is loaded and the other one is empty. Which of the two vehicles will require larger force to stop it?

A. A large force required to stop the loaded vehicle. It is because loaded vehicle has greater momentum than the empty vehicle as the mass of loaded vehicle is more than that of the empty vehicle. Thus, it requires a greater force to stop.

7. If a body is in motion, is it necessary that it is being acted upon by a force?

A. Force is required for accelerated motion. If a body possesses uniform motion, no force is required for it.

8. An athlete always runs some distance before taking a jump. Why?

A. An athlete always runs for some distance before taking a jump because inertia of motion helps to take a longer jump.

9. Explain why it is dangerous to jump out of moving bus ?

A. A passenger sitting in a moving bus has momentum. When he jumps down and stands on road, his momentum becomes zero.

If he jumps down suddenly from the moving bus and tries to stand on his feet his body will fall forward due to inertia of motion and he will be injured.

To avoid any injury, he is advised to run over some distance on the road along with (in direction of) the bus. This will slow down his rate of change of momentum and lesser force will be involved.

10. State the action and reaction in the following

a) Moving rocket

b) Firing a bullet from a gun

c) Person walking on the floor

A. a) The burnt gases are exhausted from behind with high speed giving the gases backward momentum is action

The exhausted gases import the rocket a forward momentum is reaction.

b) When the trigger of the gun is pressed bullet moves forward this is called action.

The heavy gun moves behind (recoils) with small velocity due to force of reaction.

c) Man pushes the earth backward by the toe of his foot is action.
Earth pushes the man forward is called reaction.

11. Can balanced forces stop a moving body ?

A. No.

12. On what factors does Inertia of a body depend ?

A. Inertia of a body depends on mass of a body.

13. A bird is sitting on the floor of a wire cage and the cage is in the hand of a body the bird starts flying in the cage. Is there any change in the weight of the cage.

A. When the bird starts flying in the air (inside the edge) the weight of the bird is not experienced. As result the case will appear lighter than before.

14. Action and reaction are equal and opposite but even then they do not cancel each other why?

A. Action and reaction do not act on single body. So they never cancel each other.

Action and reaction are equal in magnitude opposite in direction and they acts like pairs and always acts on two different bodies.

15. In a high jump event the athletes are made to fall on a sand bed or on a cushioned bed. Why?

A. We know, Impulse = force × time

$$J = F \times t$$

Mean while increasing time of impulse we can decrease force, because product remains constant every time.

If an athlete fall from a height on a sand bed, his feet moves inside the sand very slowly. His momentum changes slowly requiring lesser force of reaction from the sand. Thus, man is not injured.

16. If action is always equal to the reaction, explain how a horse can pull a cart.

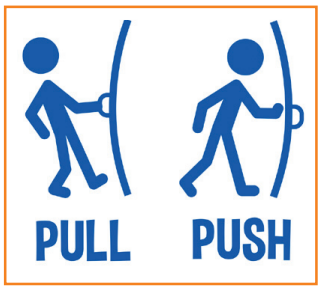
A. Cart is pulled because of the pushing of the ground in the backward direction by the horse. This force of reaction is resolved into two components and the forward component of the force of reaction is responsible for the motion of the cart.

17. Explain, why it is difficult for a fireman to hold a hose pipe which ejects large amounts of water at a high velocity.

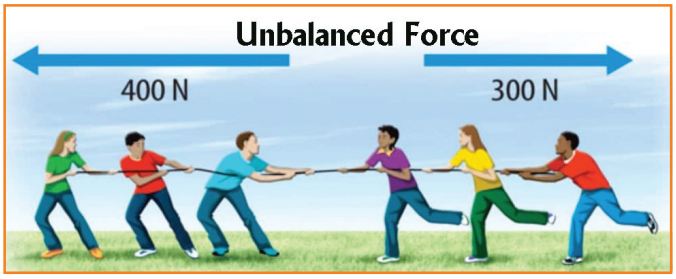
A. When water comes out with high velocity from hose pipe than an equal force of reaction acts on the hose pipe in the backward direction. Hence it becomes difficult for the fireman to hold the hose pipe.

QUICK REVIEW

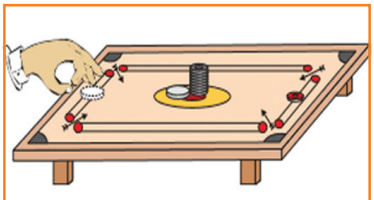
- **Force :** It is an external agent or push or pull which changes or tends to change the state of rest or the state of uniform motion of a body.



- A force can produce the following effects
  - A force or set of forces can change the speed of a body
  - A force or set of forces can change the direction of motion of a body
  - A set of forces can change the shape of a body
- **Balanced and unbalanced forces :**
  - If a set of forces acting on a body produce no acceleration in it, the forces are said to be balanced.
  - If a set of forces produces a nonzero acceleration the forces are said to be unbalanced.



- Newton has given three laws to describe the motion of bodies. These laws are known as Newton's laws of motion.
- **Newton's first law of motion :** Every body continues to remain in its state of rest or of uniform motion unless it is compelled to change its state of rest or of uniform motion, by some external force.
  - Newton's first law of motion is also called law of inertia.
  - Newton's first law of motion defines force qualitatively. It does not tell the quantity of force.
- **Inertia :** The natural tendency of an objects to resist a change in their state of rest or of uniform motion is called inertia.
  - The mass of an object is a measure of its inertia
  - Its SI unit is kilogram (kg).
- **Types of Inertia :**
  - **Inertia of rest :** It is the tendency of the body at rest to remain at rest.
  - **Inertia of motion :** It is the tendency of the body in motion to continue moving with same velocity.
  - **Inertia of direction :** It is the tendency of the body in motion to continue moving in the same direction.


Inertia of rest


Inertia of motion


Inertia of direction

➢ **Momentum :** The product of the mass of a body and its velocity is called linear momentum or momentum.

- It is a vector quantity. It is represented by symbol $\vec{p}$.
- Momentum = mass × velocity

$$\vec{p} = m\vec{v}$$

- SI unit of momentum is kg ms^{-1}, C.G.S unit of momentum is g cms^{-1}
- Every moving body possesses momentum, thus the quantity of motion in a body depends on the mass and velocity of the body.

➢ **Newton's second law of motion :** The rate of change of momentum is directly proportional to unbalanced force applied on it and change takes place along the direction of force.

➢ **Mathematical formulation of second law of motion :**

Let a force 'F' acts on a body of mass 'm' for time 't' and changes its velocity from 'u' to 'v'.

Initial momentum of a body = mu

Final momentum of a body = mv

Change in momentum of body in 't' seconds = (mv – mu)

$$\text{Rate of change of momentum} = \left(\frac{change\ in\ momentum}{time}\right)$$

$$= \frac{m(v-u)}{t} = ma \quad \left[\because a = \frac{v-u}{t}\right]$$

Rate of change of momentum = mass × acceleration.

Rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction of force.

$$\boxed{F = \frac{\Delta p}{\Delta t} = \frac{m(v-u)}{t}}$$

- The magnitude of net force acting on a body is proportional to the product of the mass of a body and its acceleration. The direction of force is the same as that of acceleration.

  F = ma
- Newton's second law is quantitative measurement of force.
- SI unit of force is newton (N)
- One newton is the force, which applied on a body of mass 1kg, produce an acceleration of $1m/s^2$.

$$\Rightarrow \boxed{1N = 1kgms^{-2}}$$

- C.G.S unit of force is dyne
- One dyne is that force which when applied on a body of mass 1g, produces an acceleration of $1cm/s^2$ in it.

$$\boxed{1\,dyne = 1\,gcms^{-2}}$$

➢ **Impulse :** The product of magnitude of force applied on a body within a short interval of time is called impulse.

- It is represented by symbol I or J
  Impulse = change in momentum

$$I = (F \times t) = (mv - mu) = (p_2 - p_1)$$

- Its SI unit is newton - second (Ns), C.G.S unit is dyne - second (dyne - s)

➢ **Newton's third law of motion :** For every action there is an equal and opposite reaction.

- Action and reaction forces are equal in magnitude and opposite in direction.
- Action and reaction forces always occur in pairs.

ANALYSE AND APPLY

1. Newton's first law of motion is also called law of _____ .
2. Action and reaction always occur is _____ .
3. 1 Newton is equal to _____ dyne.
4. The quantity of motion depends on _____ and _____
5. Unbalanced force can cause non-zero acceleration (T/F)
6. The tendency of the body in motion to continue its state of motion is called inertia of direction (T/F)
7. The rate of change of momentum is always equal to force applied on it (T/F)
8.

	Physical Quantity		SI unit
i)	Inertia	p)	N – s
ii)	Momentum	q)	kg ms^{-2}
iii)	Force	r)	kg m/s
iv)	Impulse	s)	kg

9.

	Column - I		Column - II
i)	Product of force and time	p)	Momentum
ii)	Product of mass and velocity	q)	Force
iii)	Product of mass and acceleration	r)	Impulse
iv)	Product of mass and change in velocity	s)	Inertia

OBJECTIVE EXERCISE

Multiple choice questions :

1. Calculate the mass of the body, when a force of 525 N, produces an acceleration of 3.5 m/s^2 [ ]
   a) 160 kg b) 150 kg c) 155 kg d) 175 kg

2. A driver accelerates his car first at the rate of 1.8 m/s^2 and than at the rate of 1.2 m/s^2. Calculate the ratio of the force exerted by the engine in the two cases. [ ]
   a) 4:3 b) 2:3 c) 3:2 d) 3:4

3. An object will continue to accelerate until [ ]
   a) the resultant force on it begins to decrease b) the resultant force on it is zero
   c) the velocity changes direction d) the velocity force on it is increased continuously

4. A force of 15 N acts separately on two bodies of masses 3 kg and 5 kg. The ratio of the acceleration producced in the two cases will be [ ]
   a) 5:3 b) 3:5 c) 8:15 d) 15:8

5. When a force of one newton acts on a mass of 1kg that is able to move freely, the object moves with a [ ]
   a) speed of 1 ms^{-1} b) speed of 1 kms^{-1}
   c) acceleration of 10 ms^{-2} d) acceleration of 1 ms^{-2}

6. A and B are two objects with masses 6 kg and 34 kg respectively [ ]
   a) A has more inertia than B b) B has more inertia than A
   c) A and B are having same inertia d) none of the above is true

7. Convert 1kg-wt into dynes [ ]
   a) 9.81×10^4 dyne b) 98.1×10^5 dyne c) 9.81×10^5 dyne d) 98.1×10^7 dyne

8. If two bodies collide in the absence of any external force, what will be the total change in the momentum of the system? [ ]
   a) one b) zero c) >1 d) Both (a) and (b)

9. Find the magnitude of the net force on a 20 kg mass if it accelerates uniformly from rest to 5.8 m/s in 3 s. [ ]
   a) 44.4 N b) 38.6 N c) 22.2 N d) 55.5 N

10. The action and reaction forces act [ ]
    a) on different bodies always b) on same body always
    c) on same body,sometimes d) on different bodies,sometimes

Assertion & Reason Tpye Questions :

a) Both A and R are correct and R is the correct explanation of A
b) Both A and R are correct but R is not the correct explanation of A
c) A is correct, R is incorrect
d) A is incorrect, R is correct

11. **Assertion (A) :** When a bus starts suddenly, a person standing falls back wards [ ]
    Reason (R) : It is due to inertia of rest.

12. **Assertion (A) :** A body can have acceleration even if its velocity is zero at a given instant of time
Reason (R) : A body is momentarily at rest when it reverses its direction of motion. [ ]

13. **Assertion (A) :** No force is required by the body to remain in a state of uniform motion.
Reason (R) : In uniform linear motion, acceleration has a finite value [ ]

14. **Assertion (A) :** In the case of free fall of the lift, then man will feel weightlessnes [ ]
Reason (R) : In freely falling, acceleration of lift is equal to acceleration due to gravity.

OLYMPIAD CORNER

1. Galileo did his experiments on inclined planes with smooth surfaces and observed that [ ]
a) As smoother the surface, the farther the ball travelled
b) As rough the surface, the farther the ball travelled
c) As smoother the surface, the nearer the ball travelled
d) None of these

2. It is recommended that the air pressure in motor car tyres be reduced for a motion of the motor car over sand because. [ ]
a) inflated tyres cause high pressure on the sand b) deflated tyres cause high pressure on the sand
c) inflated tyres cause low pressure on the sand d) deflated tyres cause low pressure on the sand

3. A long piece of rubber is wider than it is thick. When it is stretched in length by some (finite) amount:
a) Its thickness decreases but its width increases [ ]
b) Its thickness decreases but its width remains constant
c) Its thickness increases but its width decreases
d) both its thickness and width decrease

4. A rocket of mass 1000 kg exhaust gases at a rate of 4 kg / sec with a velocity 3000 m/s the thrust developed on the rocket is [ ]
a) 120 N b) 800 N c) 12000 N d) 200 N

5. A man is at rest in the middle of a pond on perfectly smooth ice. He can get himself to the shore by making use of Newton's. [ ]
a) First law b) Second law c) Third law d) All of these laws

6. Which of the following facts is/are direct evidence (s) suppporting Newton's first law of motion?
a) A feather and a coin spend equal time to reach the ground when dropped from the same height on the Moon surface. [ ]
b) A satellite orbits around the Earth with uniform speed without supply of fuel.
c) A man is thrown forward on a bus which stops suddenly.
d) A man walk on the horizontal road

7. Two bodies of mass M and m (M > m) are released freely in air, acceleration of the body [ ]
a) 'M' is more b) 'm' is more c) equal d) depends on height

8. A stone, when thrown on a glass window smashes the window pane to pieces. But a bullet fired from a gun passes through making a hole. Why [ ]
a) inertia of motion b) inertia of direction
c) inertia of rest d) less force applied by bullet

9. By applying a force of 1 N, one can hold a body whose mass is approximately equal to [ ]
a) 100 mg b) 100 g c) 1 kg d) 10 kg

10. A coin flicked across a table stops because [ ]
a) no force acts on it b) it is very heavy
c) the table exerts a frictional force on it d) the earth attracts it

11. If a constant force acts on a body initially kept at rest, The distance moved by the body in time 't' is proportional to its [ ]
a) t b) t^2 c) t^3 d) t^4

12. Which of the following has the largest inertia ? [ ]
a) A pin b) An inkpot c) Your physics book d) Your body

13. When a horse pulls a cart, the force that helps the horse to move forward is the force exerted by
a) the cart on the horse b) the ground on the horse [ ]
c) the ground on the cart d) the horse on the ground

14. A car accelerates on a horizontal road due to the force exerted by [ ]
a) the engine of the car b) the driver of the car c) the earth d) the road.

15. A girl of mass 50 kg jumps out of a rowing boat of mass 300 kg on to the bank with a horizontal velocity of 3 m/s.With what velocity does the boat begin to move backwards? [ ]
a) 0.6 ms^{-1} b) 0.5 ms^{-1} c) 0.7 ms^{-1} d) 0.55 ms^{-1}

16. When two bodies A and B interact with each other, A exerts a force of 10 N on B towards east.What is the force exerted by B on A? [ ]
a) A exerts 10 N force on B towards West b) B exerts 20 N force on A towards East
c) B exerts 10 N force on A towards West d) A exerts 20 N force on B towards East

17. A force F_1 acting on a 2.0 kg body produces an acceleration of 2.5 m/s^2. Another force F_2 acting on a 5.0 kg body produces an acceleration of 2.0 m/s^2. Find the ratio F_2/F_1 [ ]
a) 1:2 b) 2:1 c) 3:2 d) 2:3

18. A force produces an acceleration of 5.0 cm/s^2. When it acts on a body of mass 20 g. find the force in newton. [ ]
a) $2.0\times10^{-3}N$ b) $3.0\times10^{-3}N$ c) $1.0\times10^{-3}N$ d) $1.0\times10^{-4}N$

19. A bird is sitting on the floor of a wire cage and the cage is in the hand of a body the bird starts flying in the cage. then [ ]
a) weight of the cage lighter than before b) weight of the cage heavier than before
c) weight of the cage remains same d) none of these

20. A stone of 1kg is thrown with a velocity of 20 ms^{-1} across the frozen surface of a lake and comes to rest after travelling a distance of 50 m. The force of friction between the stone and the ice
a) 4 N b) 3 N c) 2 N d) 1 N [ ]

3 GRAVITATION

WISE UP

- A physical quantity which can change or tries to change state of motion of a body is called force.
- The strength of force is usually expressed by its magnitude.
- Force has both magnitude and direction. If the magnitude or the direction changes the effect of force can change.
- There are various types of forces such as muscular, magnetic, electrostatic, gravitational, buoyant and frictional.
- **Contact force :** It is a force applied to a body by another body that is in contact.

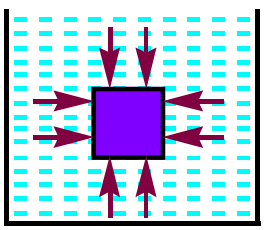
  Ex : Muscular force, Tension, Friction, etc.,
  - The force resulting due to the action of muscles is known as the muscular force.
  - Friction force always acts on all the moving parts and its direction is always opposite to the direction of motion.
- **Non contact force :** It is a force which acts on object without coming into actual contact.

  Ex : Gravitational force, magnetic force, electric force, etc.,
  - The force which is responsible to the fall of objects towards the earth is called **Gravitational force.**
  - Every object in universe whether small or large, exerts a force on every other object. This force is called Gravitational force.
  - The force exerted by the charged body on another charged body (or) uncharged body is called **Electrostatic force**.
- Equations of motion for a body moving with constant acceleration along a straight line.

  i) v = u + at ii) $s = \left(\frac{u+v}{2}\right)t$ iii) $s = ut + \frac{1}{2}at^2$ iv) $v^2 = u^2 + 2as$
- **Pressure :** Pressure is the perpendicular force acting on a unit surface area.

$$\therefore P = \frac{F}{A}$$

- Liquids and gases apply pressure on the surfaces of the container.
- Pressure exerted by atmospheric air is called atmospheric pressure.
- Atmospheric pressure decreases with increase in height or altitude.
- Pressure of a column of liquid depends on its depth. The more the depth of the liquid column, the more is the pressure.
- Fluids (Liquids and gases) exert pressure in all directions.



NCERT TEXTUAL QUESTIONS

1. State the universal law of gravitation ? (Understanding)

A. Every body in the universe attracts every other body with a force which is directly proportional to the product of their masses and inversly proportional to the square of the distance between their centres.

2. Write the formula to find the magnitude of the gravitational force between the earth and an object on the surface of the earth. (Understanding)

A. If 'M' is mass of the earth, 'm' is the mass of the object on the surface of the earth and R is the distance between their centres then force of attraction between the earth and the object placed on its surface is

$$F = \frac{GmM}{R^2}$$

3. What do you mean by free fall ? (Understanding)

A. All objects are falling towards the earth and only under the action of gravitational force of the earth are said to be in the state of free fall.

4. What do you mean by acceleration due to gravity ? (Understanding)

A. When an object is in the state of free fall, then there is no change in the direction of motion of the objects. During the free fall, magnitude of the velocity of the falling objects goes on increasing and thus there is some acceleration produced in a body which is in the state of free fall. Thus acceleration is called acceleration due to gravity is defined as the acceleration produced in a body which is in the state of free fall.

5. What are the differences between mass of an object and its weight ? (Creating)

A.

Mass	Weight
1) It is the quantity of matter contained in given the body.	1) Weight of a body is the force with which the body is attracted towards the centre of the earth.
2) Mass is a scalar quantity.	2) Weight is a vector quantity.
3) Mass of an object is never zero.	3) Weight of an object is zero at the centre of the earth.
4) Mass of an object is always constant.	4) Weight of an object varies from place to place.
5) SI unit of mass is kilogram.	5) SI unit of weight is newton.

6. Why is the weight of an object on the moon, $\frac{1}{6}$th its weight on the earth ? (Applying)

A. $M_e = 6 \times 10^{24}$ kg, $M_m = 7.4 \times 10^{22}$ kg, $R_e = 6,400$ km and $R_m = 1,740$ km

$W = mg$ and $g = \frac{GM}{R^2} \Rightarrow W = \frac{GMm}{R^2}$,

$$W_e = \frac{GM_e m}{R_e^2},\ W_m = \frac{GM_m m}{R_m^2} \Rightarrow \frac{W_m}{W_e} = \frac{M_m}{M_e} \times \frac{R_e^2}{R_m^2} = \frac{1}{6} \Rightarrow W_m = \frac{W_e}{6}$$

i.e Weight of an object on the moon is $\frac{1}{6}th$ of its weight on the surface of the earth.

7. Why it is difficult to hold a school bag having a strap made of a thin and strong string? (Analyzing and Evaluating)

A. The thin string exerts a large pressure on our hand due to its smaller area. Hence, we feel uncomfortable.

8. What do you mean by buoyancy? (Understanding)

A. The upward force acting on a body immersed in a fluid is called upthrust or force of buoyancy and the phenomenon is called buoyancy.

9. When does an object float or sink when placed on the surface of water? (Creating)

A. i) An object sinks in water when its density is greater than that of water.

ii) An object floats on water when its density is less than that of water.

10. You find your mass to be 42 kg on a weighing machine. Is your mass more or less than 42 kg? (Analyzing and Evaluating)

A. More than 42 kg the weighing machine reads slightly less value due to the upthrust of air acting on our body.

11. You have a bag of cotton and an iron bar, each indicating a mass of 100 kg when measured on a weighing machine. In reality one is heavier than other. Can you say which one is heavier and why? (Analyzing and Evaluating)

A. The cotton bag is heavier than the iron bar. The cotton bag experiences larger upthrust of air than the iron bar. So, the weighing machine indicates a smaller mass for cotton bag than its actual mass.

NCERT TEXTUAL EXERCISE QUESTIONS

1. How does the force of gravitation between two objects change when the distance between them is reduced to half ? (Applying)

A. As $F \propto \frac{1}{r^2}$ [inverse square law]

$$\frac{F_2}{F_1} = \frac{r_1^2}{r_2^2} = \frac{r_1^2}{\left(\frac{r_1}{2}\right)^2} = 4$$

Force becomes four times.

2. Gravitational force acts on all objects in proportion to their masses. Why then, a heavy object does not fall faster than a light object ? (Understanding)

A. Force = Mass × Acceleration.

$$\text{Acceleration} = \frac{force}{mass} \Rightarrow \text{Force} \propto \text{Mass}$$

But acceleration is same for all falling bodies.

This acceleration is called acceleration due to gravity.

Also from the relation v = u + gt

we get v = gt [when u = 0]

i.e for same 't', v will be same for all bodies [∵ 'g' is same for all bodies]

3. What is the magnitude of the gravitational force between the earth and a 1 kg object on its surface ? (Mass of the earth is 6×10^{24} kg and radius of the earth is 6.4×10^{6} m). (Applying)

A. From Relation $F = \frac{(GM)m}{R^2}$

$F = mg$

when m = 1kg and g = 9.8 ms^{-2},

then $F = 1 \times 9.8 = 9.8$ N

4. The earth and the moon are attracted to each other by gravitational force. Does the earth attract the moon with a force that is greater or smaller or the same as the force with which the moon attracts the earth ? Why ? (Creating)

A. Gravitational force is mutual. It is equal and opposite on the two bodies.

5. If the moon attracts the earth, why does the earth not move towards the moon ? (Inferential and Evaluation)

A. For same gravitational force, there is less acceleration on the huge earth. Thus earth does not move.

6. What happens to the force between two objects, if (Applying)

1) the mass of one object is doubled ?

2) the distance between the objects is doubled and tripled ?

3) the masses of both objects are doubled ?

A. Force of gravitation between two bodies $\boxed{F = \frac{Gm_1m_2}{r^2}}$

i) $F \propto m_1$, Force becomes double.

ii) $F \propto \frac{1}{r^2}$. Force becomes one - fourth at double distance and one - ninth at triple distance.

iii) $F \propto m_1m_2$. Force becomes four times.

7. What is the importance of universal law of gravitation ? (Understanding)

A. i) All planets revolve around the sun due to the gravitational force between the sun and the planet

ii) Tides in oceans are due to the gravitational force between the moon and water in oceans.

iii) Atmosphere of earth is possible due to the gravitational force of earth.

iv) Artificial satellite move round the earth due to the gravitational force between the earth and the satellite.

v) Snow fall and rainfall is possible due to the gravitational pull of earth.

8. What is the acceleration of free fall ? (Understanding)

A. Acceleration of free fall is the acceleration due to gravity. It is same for bodies of all masses and its value is 9.8 m/s^2 on the surface of the earth.

9. What do we call the gravitational force between the earth and an object ? (Understanding)

A. The gravitational force between the earth and object is called the weight of the object.

10. Amit buys few grams of gold at the poles as per the instruction of one of his friends. He hands over the same when he meets him at the equator. Will the friend agree with the weight of gold brought ? If not, why ? [Hint : The value of g is greater at the poles than at the equator]. (Applying)

A. No, The value of g is greater at the poles than at the equator.

His friend will not agree with the weight of the gold.

$$\frac{Weight\ at\ equator\ (w_e)}{Weight\ at\ poles\ (w_p)} = \frac{m \times g_e}{m \times g_p} = \frac{g_e}{g_p}$$

As value of 'g' is less at equator then its value of poles, weight will be found to be lesser at the equator.

11. Why will a sheet of paper fall slower than one that is crumped into a ball ? (Analyzing and Evaluating)

A. Sheet of paper occupies more space and experience more air resistance. Thus, it fall becomes slow.

12. Gravitational force on the surface of the moon is only $\frac{1}{6}$ as strong as gravitational force on the earth. What is the weight in newtons of a 10 kg object on the moon and on the earth ? (Application)

A. $$\frac{F_{moon}}{F_{earth}} = \frac{W_{moon}}{W_{earth}} = \frac{m \times g_{moon}}{m \times g_{earth}} = \frac{1}{6}$$

$$= \frac{g_{moon}}{g_{earth}} = \frac{1}{6}$$

$g_{earth} = 9.8\ m/s^2$

$$g_{moon} = \frac{9.8}{6} = 1.63\ m/s^2$$

Mass, m = 10 kg

Weight on the moon, $w_{moon} = m \times g_{moon}$

$= 10 \times 1.63$

$= 16.3\ N$

Weight on the earth, $w_{earth} = m \times g_{earth}$

$= 10 \times 9.8$

$$\boxed{w_{earth} = 98\ N}$$

13. A ball is thrown vertically upwards with a velocity of 49 m/s. (Applying)

Calculate : 1) The maximum height to which it rises.

2) The total time it takes to return to the surface of the earth.

A. Initial velocity, u = 49 m/s, Final velocity, v = 0 m/s

Acceleration of ball, a = g = –9.8 m/s^2 (for upward motion)

Maximum Height reached by the ball,

s = h = ?

$v^2 - u^2 = 2as$ changes to $v^2 - u^2 = -2gh$

$$\Rightarrow \quad h = \frac{v^2 - u^2}{-2g} = \frac{0-(49\times 49)}{-2\times 9.8} \Rightarrow h = 122.5 \text{ m}$$

Time of ascent $t = \frac{v-u}{a} = \frac{0-49}{-9.8} \Rightarrow t = 5$ s

Total time for journey $\boxed{T = 2t = 10\ s}$.

14. A stone is released from the top of a tower of height 19.6 m. Calculate its final velocity just before touching the ground. (Applying)

A. Initial velocity, u = 0 m/s

Acceleration of the stone, a = g = 9.8 m/s^2

Height covered, s = h = 19.6 m

$v^2 = u^2 + 2gh$

$= 0 + 2gh$

$v^2 = 2 \times 9.8 \times 19.6 = (19.6)^2$

$\Rightarrow$ v = 19.6 m/s

15. A stone is thrown vertically upward with an initial velocity of 40 m/s. Taking g = 10 m/s^2, find the maximum height reached by the stone. What is the net displacement and the total distance covered by the stone ? (Applying)

A. Initial velocity, u = 40 m/sec

Acceleration of the stone, a = g = –10 m/s^2

Final velocity at the highest point, v = 0 m/s

$$h = \frac{v^2 - u^2}{2(-g)}$$

$$= \frac{0-(40\times 40)}{2\times -10}$$

$$\boxed{h = 80\ m}$$

As the stone reaches the ground

Net displacement = 80 – 80 = 0 m

Total distance = 80 + 80 = 160 m.

16. Calculate the force of gravitation between the earth and the Sun, given that the mass of the earth = 6×10^{24} kg and of the Sun = 2×10^{30} kg. The average distance between the two is 1.5×10^{11} m. (Applying)

A. Mass of sun, $m_1 = 2 \times 10^{30}$ kg

Mass of earth, $m_2 = 6 \times 10^{24}$ kg

Distance between, then, $r = 1.5 \times 10^{11}$ m

then $F = \frac{Gm_1m_2}{r^2}$

$$= \frac{6.67 \times 10^{-11} \times 2 \times 10^{30} \times 6 \times 10^{24}}{\left(1.5 \times 10^{11}\right)^2}$$

$$= \frac{6.67 \times 2 \times 6 \times 10^{43}}{1.5 \times 1.5 \times 10^{22}}$$

$$\boxed{F = 3.56 \times 10^{22}\, N}$$

17. A stone is allowed to fall from the top of a tower 100 m high and at the same time another stone is projected vertically upwards from the ground with a velocity of 25 m/s. Calculate when and where the two stones will meet. (Applying)

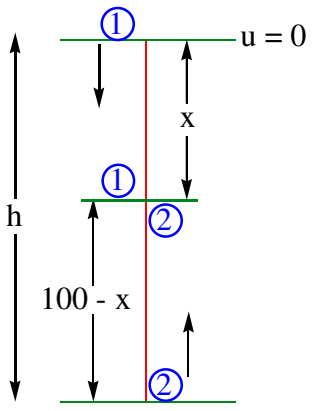
A. Let the stones meet after t sec at x m below the top of tower.

The downward journey for the first stone,

$$x = \frac{1}{2}gt^2 \quad \text{..... (1)}$$

upward journey for the second stone

$$100 - x = 25\ t - \frac{1}{2}gt^2 \quad \text{..... (2)}$$



From (1) and (2)

$$100 - \frac{1}{2}gt^2 = 25t - \frac{1}{2}gt^2$$

$$100 = 25t$$

$$\boxed{4\ s = t}$$

stones meet after 4 second,

$$x = \frac{1}{2}gt^2$$

$$= \frac{1}{2} \times 10 \times 4^2$$

$$\boxed{x = 80\ m}$$

Stones meet after 4 second, 80 metre below the top of the tower.

18. A ball thrown up vertically returns to the thrower after 6 s. Find (Applying)

a) the velocity with which it was thrown up

b) the maximum height it reaches, and

c) its position after 4 s.

A. Time of flight T = 6 s

So time of ascent or descent (t) = 3 s

Final velocity at the highest point , v = 0 m/s

Acceleration due to gravity, g = – 9.8 m/s^2

a) $v = u + gt \Rightarrow v = u - gt$

$\Rightarrow$ $u = v + gt$ [for upward direction]

$\Rightarrow$ $= 0 + (-9.8 \times 3)$

$\boxed{u = -29.4 m/s}$

i.e., 29 ms^{-1} upwards,

b) $h = \left(\frac{u+v}{2}\right) \times t$

$= \left(\frac{29.4+0}{2}\right) \times 3\,s \Rightarrow \boxed{44.1m = h}$

c) 4 second means 1 s, after Reaching highest point.

For downward journey $h = \frac{1}{2} gt^2$

$= \frac{1}{2} \times 9.8 \times 1^2$ $\boxed{h = 4.9\ m}$

4.9 m below the highest point (44.1 – 4.9) m height above the ground = 39.2 m.

19. In what direction does the buoyant force on an object immersed in a liquid act? (Creating)

A. The buoyant force acts on an object in the vertically upward direction, through the centre of gravity of the displaced fluid. It is called buoyancy.

20. Why does a block of plastic released under water come up to the surface of water? (Creating)

A. The upthrust or the buoyant force exerted by water brings the plastic block to the surface of water.

21. The volume of 50 g of a substance is 20 cm^3. If the density of water is 1 g cm^{-3}, will the substance float or sink? (Applying)

A. Mass of substance = 50 g

Volume of substance = 20 cm^3

$$\text{Density of substance} = \frac{\text{Mass}}{\text{Volume}} = \frac{50\,g}{20\,cm^3} = 2.5\,g/cm^3$$

Density of water = 1 g cm^{-3}

As the density of substance is greater than that of water, so the substance will sink in water.

22. The volume of a 500 g sealed packet is 350 cm^3. density of water is 1 g cm^{-3} What will be the mass of the water displaced by this packet? (Applying)

A. Mass of packet = 500 g

Volume of packet = 350 cm^3

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} = \frac{500\ g}{350\ cm^3} = 1.43\ gcm^{-3}$$

The sealed packet will sink in water because its density is more than that of water, mass of the water displaced is 350g.

TEXT BOOK SOLVED PROBLEMS

1. The mass of the earth is 6×10^{24} kg and that of the moon is 7.4×10^{22} kg. If the distance between the earth and the moon is 3.84×10^5 km, calculate the force exerted by the earth on the moon. (Take G = 6.7×10^{-11} Nm^2 kg^{-2}) (Applying)

A. The mass of the earth, M = 6×10^{24} kg. The mass of the moon, m = 7.4×10^{22} kg

The distance between the earth and the moon,

d = 3.84×10^5 km

= $3.84 \times 10^5 \times 1000$ m = 3.84×10^8 m

G = 6.7×10^{-11} N ms^2 kg^{-2}

The force exerted by the earth on the moon is

$$F = G\frac{M \times m}{d^2} = \frac{6.7 \times 10^{-11} Nm^2 kg^{-2} \times 6 \times 10^{24} kg 7.4 \times 10^{22} kg}{(3.84 \times 10^8 m)^2} = 2.02 \times 10^{20}\ N$$

Thus, the force exerted by the earth on the moon is 2.02×10^{20} N.

2. A car falls off a ledge and drops to the ground in 0.5 s. Let g = 10 ms^{-2} (for simplifying the calculations). (Applying)

i) What is its speed on striking the ground ?

ii) What is its average speed during the 0.5 s ?

iii) How high is the ledge from the ground ?

A. Time, t = 1/2 second

Initial velocity, u = 0 ms^{-1}

Acceleration due to gravity, g = 10 ms^{-2}

Acceleration of the car, a = + 10 ms^{-2}

i) speed v = at

v = 10 ms^{-2} × 0.5 s

= 5 ms^{-1}

ii) average speed $= \frac{u+v}{2}$ = (0 ms^{-1} + 5 ms^{-1}) / 2 = 2.5 ms^{-1}

iii) disance travelled, s = 1/2 at^2

= 1/2 × 10 ms^{-2} × (0.5 s)^2

= 1/2 × 10 ms^{-2} × 0.25 s^2

= 1.25 m

Thus,

i) its speed on striking the ground = 5 ms^{-1}

ii) its average speed during the 0.5 s = 2.5 ms^{-1}

iii) height of the ledge from the ground = 1.25 m.

3. An object is thrown vertically upwards and rises to a height of 10 m. Calculate (i) the velocity with which the object was thrown upwards and (ii) the time taken by the object to reach the highest point. (Applying)

A. Distance travelled, s = 10 m

Final velocity, v = 0 ms^{-1}

Acceleration due to gravity, g = 9.8 ms^{-2}

Acceleration of the object , a = – 9.8 ms^{-2} (upward motion)

i) $v^2 = u^2 + 2a\,s$

$0 = u^2 + 2 \times (-9.8\ ms^{-2}) \times 10\ m$

$-u^2 = -2 \times 9.8 \times 10\ m^2\ s^{-2}$

$u = \sqrt{196} ms^{-1}$

u = 14 ms^{-1}

ii) $v = u + at$

$0 = 14\ ms^{-1} - 9.8\ ms^{-2} \times t$

t = 1.43 s .

Thus,

i) Initial velocity, u = 14 ms^{-1}, and

ii) Time taken, t = 1.43 s.

4. Mass of an object is 10 kg. what is its weight on the earth ? (Applying)

A. Mass, m = 10 kg

Acceleration due to gravity, g = 9.8 ms^{-2}

$W = m \times g$

$W = 10\ kg \times 9.8\ ms^{-2} = 98\ N$

Thus, the weight of the object is 98 N.

5. An object weighs 10 N when measured on the surface of the earth. What would be its weight when measured on the surface of the moon ? (Applying)

A. We know,

weight of object on the moon

= (1 / 6) × its weight on the earth.

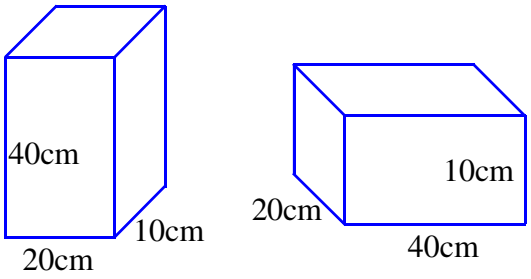
That is,

$$W_m = \frac{W_e}{6} = \frac{10}{6} N$$

= 1.67 N.

Thus, the weight of object on the surface of the moon would be 1.67 N.

6. A block of wood is kept on a table top. The mass of wooden block is 5 kg and its dimensions are 40 cm × 20 cm × 10 cm.



Find the pressure exerted by the wooden block on the tables top if it is made to lie on the stable top with its sides of dimensions (a) 20 cm × 10 cm (b) 40 cm × 20 cm. (Applying)

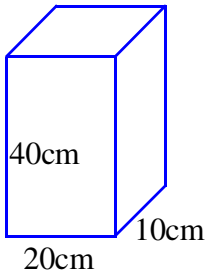
a) 20 cm × 10 cm.

A. The mass of the wooden block = 5 kg

The dimensions = 40 cm × 20cm × 10 cm

Here, the weight of the wooden block applies a thrust on the table top.

That is ,



Thrust = F = m × g

= 5 kg × 9.8 ms^{-2}

= 49 N

Area of a side = length × breath

= 20 cm × 20 cm

= 200 cm^2 = 0.02 m^2

Pressure $= \frac{49N}{0.02m^2} = 2450Nm^{-2}$

b) 40 cm × 20 cm.

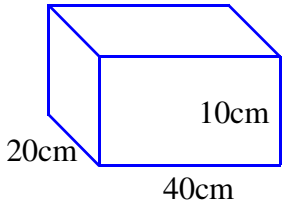
A. When the block lies on its side of dimensions 40 cm × 20 cm, it exerts the same thrust.

Area = length × breadth

= 40 cm × 20 cm

= 800 cm^2

= 0.08 m^2



Pressure $= \frac{49N}{0.08m^2} = 612.5\ Nm^{-2}$

The pressure exerted by the side 20 cm × 10 cm is 2450 Nm^{-2} and by the side 40 cm × 20 cm is 612.5 N m^{-2}.

ADDITIONAL QUESTIONS

I. COMPETENCY - DEMONSTRATE KNOWLEDGE AND UNDERSTANDING

1. State universal law of gravitation. What is SI unit of G ?

A. Every body in the universe attracts every other body with a force which is directly proportional to product of their masses and inversely proportional to the square of the distance between their centres.

$$\text{SI unit of } G = \frac{Nm^2}{kg^2}.$$

2. Define one Kilogram - weight. How many newtons are there in 1 kg-wt ?

A. One kilogram - weight (kg - wt) is the force of gravity acting on a body of mass 1 kg.
1 kg - wt = 1 kg × 9.8 m/s^2 = 9.8 N.

3. Write and define the S.I. unit of pressure?

A. The S.I. unit of pressure is Nm^{-2} or pascal. If a thrust of 1N is acted on, a surface of area 1m^2, then pressure experienced by surface is 1 pascal.

4. Write and define the S.I. unit of density?

A. The S.I. unit of density is kg/m^3 . If a body of mass 1 kg occupies a volume of 1 m^3, then the density of a body is said to be 1 kg / m^3.

5. Name the device which is used for measuring the purity of milk?

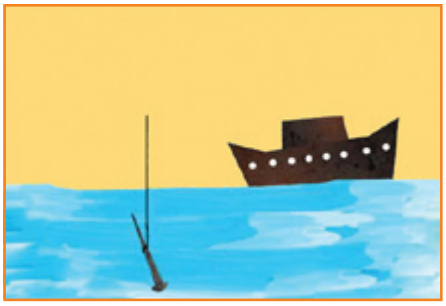
A. Lactometer.

6. Why does a mug full of water feel lighter inside water ?

A. Because of upthrust of water exerted on the mug.

7. Explain why a ship made of iron will float but an iron nail will sink in water ?

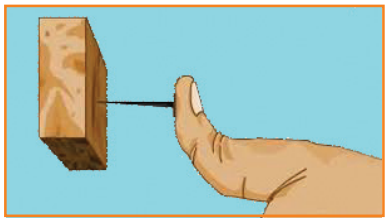
A. A ship of iron (or) steel has more volume than a nail, so, the buoyant force exerted by the water on the ship is more than on the nail, so ship floats and nail sinks.



8. Define the terms thrust and pressure.

A. **Thrust :** The total force acting on a body perpendicular to its surface is called thrust.

Pressure : The thrust acting per unit of the surface area is called pressure.



9. a) Name the force that accelerate a body in free fall.

b) Does a stone falling towards the earth pulls the earth towards it? If yes, then why is the earth not seen moving towards the stone ?

A. a) Freely falling body is attracted by force with which earth attracts a body towards its centre is called force of gravity.

b) Stone also attracts the earth with the same gravitational force, but this produce very less acceleration on the huge mass of the earth. Thus earth does not move.

10. Why is G called the universal constant ?

A. 'G' value is same at any where in the universe. It is independent of the nature of separation of two objects in the medium. It is independent of other quantities like height or depth etc.

3. What is the mass and weight of a body on the moon's surface if its weight 120 N on the Earth's surface ?

A. Weight of a body on Earth's surface = 120 N

The weight of the body on moon's surface = $\frac{1}{6} \times 120 = 20$ N

Thus, mass of the body = $\frac{120}{10} = 12$ kg

Mass is always constant so mass of the body on moon's surface = 12 kg.

11. Show that if the earth attracts two bodies A and B placed at the same distance from the centre of the earth with the same force, then their masses are equal.

A. From relation $F = \frac{Gm_1m_2}{r^2}$

$$F = \frac{GMm}{r^2}$$

we know that forces are same and they are at the same distance from the centre of earth so

$$F = \frac{GMm_A}{r^2} = \frac{GMm_B}{r^2}$$

Clearly G, M and 'r' are same for two objects so $\boxed{m_A = m_B}$.

12. Name two forces which act on a body immersed in a liquid gives the directions in which they act.

A. Two forces which act on a body immersed in a liquid are

i) Weight of the body acting downward

ii) An upthrust acting upward.

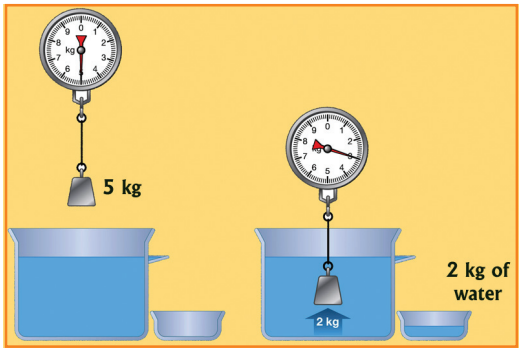
13. Explain why the volume of floating Ice above the brine solution is higher as compared to that in the water.

A. It is because the density of brine solution is more than that of the fresh water Thus upthrust experienced by the floating Ice in brine solution is more than upthrust due to fresh water. Hence the volume of Ice above the brine solution is more as compared to that in fresh water.

14. Explain Archimedes principle with help of an activity ?

A. **Archimedes principle :** When a body is immersed fully or partially in a fluid, it experiences an upward force that is equal to the weight of the fluid displaced by it.

Activity :



i) Take a piece of stone and tie it to one end of a spring balance.

ii) Suspend the stone by holding the balance as shown in Figure.

iii) Note the reading on the spring balance due to the weight of the stone.

iv) Now, slowly dip the stone in the water in a container as shown in Figure.

v) You will find that the reading of the balance decreases due to buoyant force as the stone is gradually lowered in the water and water displaces.

vi) The displaced water is collected into measuring jar.

vii) If you observe the loss of weight of body is equal to weight of displaced water.

15. Write applications of Archimedes principle ?

A. i) It is used in designing ships and submarines.

ii) Lactometers, which are used to determine the purity of a sample of milk.

iii) Hydrometers used for determining density of liquids.

16. A sharp knife cuts better than a blunt one. Why?

A. Area of sharp edge is much less than the area of blunt edge. For the same total force, the effective force per unit area is more for the sharp edge than for the blunt edge, so sharp edge cuts better than a blunt one.

II. COMPETENCY - APPLICATION OF KNOWLEDGE/CONCEPTS

1. Suppose your weight on the surface of the earth is 600 N and you are taken to a height equal to the radius of the earth, then what will be your weight there ?

A. Weight on the surface of the earth is $W = \frac{GMm}{R^2}$

At a height equal to the radius of the earth, the distance from the centre of the earth = R + R = 2R.

Therefore, the weight will become.

$$W' = \frac{GMm}{(2R)^2} = \frac{1}{4}\frac{GMm}{R^2} = \frac{1}{4}W = \frac{1}{4} \times 600N = 150N$$

2. At what height above the earth's surface would the value of acceleration due to gravity be half of that is on the surface ? Calculate.

A. We know 'g ' value on the surface of earth is $g = \frac{GM}{R^2}$

as height increases above the surface of the earth 'g' value decreases its formula is $g_h = \frac{GM}{(R+h)^2}$

From the statement 'g' value at a height 'h' metre above the surface earth = half of the 'g' value on the earth.

$$g_h = \frac{g}{2} \Rightarrow \frac{GM}{(R+h)^2} = \frac{GM}{R^2 \times 2}$$

$2R^2 = (R + h)^2$

$\Rightarrow$ $R + h = \sqrt{2}R$

$h = (\sqrt{2} - 1) \times R$

$$\boxed{h = (\sqrt{2} - 1) \times R}.$$

3. A body weigh 30 kg on the surface of earth. How much would it weigh on the surface of planet whose mass is $\left(\frac{1}{9}\right)$ the mass of the earth and radius is half that of earth.

A. m = 30 kg [same every where in the universe]

weight of a body on planet is $W_p = m \times g_p$.

Acceleration on the planet, $g_p = \frac{G \times M_p}{R_p^2}$

Mass of planet $M_p = \frac{1}{9}M$, Radius of planet $R_p = \frac{1}{2}R$

$$g_p = \frac{G \times M}{9 \times R^2} \times 4 = \frac{4}{9}\frac{GM}{R^2}$$

We know 'g' on earth, $g = \frac{GM}{R^2} = 10 \text{ m/s}^2$

$$g_p = \frac{4}{9} \times 10 \Rightarrow g_p = \frac{40}{9}$$

$\therefore$ Weight of the body on the planet $(w_p) = m_p \times g_p = \frac{30 \times 40}{9} = \frac{1200}{9} = 133.33$ N

4. The gravitational force between two objects is 100 N. How should the distance between the objects be changed so that force between them becomes 50 N?

A. From relation $F = \frac{Gm_1m_2}{r^2}$

So $F \propto \frac{1}{r^2} \Rightarrow \frac{F_1}{F_2} = \frac{r_2^2}{r_1^2}$

$$\frac{100}{50} = \frac{r_2^2}{r_1^2} \Rightarrow 2r_1^2 = r_2^2 \Rightarrow r_2 = \sqrt{2}r_1$$

If distance between them becomes $\sqrt{2}$ times the original distance then the force becomes 50N.

5. A ball is droped from a height of 20 m. A second ball is thrown from the same height after one second with initial velocity 'u' if both the balls reach the ground at the same time calculate the initial velocity of the second ball. Do they hit the ground at the same velocity (g = 10 m/s^2) ?

A. For first ball,

u = 0 m/s , g = 10 m/s^2 , h = 20 m ,

$$h = ut + \frac{1}{2}gt^2$$

$$\Rightarrow \quad 20 = 0 \times t + \frac{1}{2} \times 10 \times t^2$$

$\Rightarrow$ $5t^2 = 20 \Rightarrow t^2 = 4 \Rightarrow t = 2s$

$v^2 = u^2 + 2gh$

$v^2 = 0 + 2 \times 10 \times 20 \Rightarrow v^2 = 400 \Rightarrow v = 20$ m/s

For second ball,

h = 20 m, t = 2 – 1 = 1 s

$$h = ut + \frac{1}{2}gt^2$$

$$\Rightarrow \quad 20 = u \times 1 + \frac{1}{2} \times 10 \times 1^2$$

$\Rightarrow$ u = 20 – 5 = 15 m/s

6. Suppose gravitational pull varies inversely as nth power of the distance. Show that the time period of a planet in circular orbit of radius R around the sun will be proportional to $R^{(n+1)/2}$.

A. As gravitational pull of sun on the planet provides necessary centripetal force to the planet, Therefore,

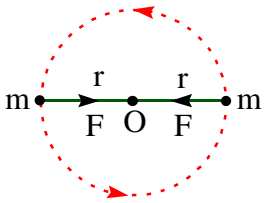
$$\frac{GMm}{R^n} = mR\left(\frac{2\pi}{T}\right)^2 = \frac{4\pi^2 mR}{T^2}$$

(or) $T^2 = \frac{4\pi^2 mR^{n+1}}{GMm} \Rightarrow T = \frac{2\pi}{\sqrt{GM}} R^{(n+1)/2}$

Hence $T \propto R^{(n+1)/2}$.

7. Two particles of equal mass (m) move in a radius (r) under the action of their mutual gravitational attraction. Find the speed of each particle.

A. The two particles will move on a circular path if they always remain diametrically opposite as in below figure.



So that gravitational force on one particle due to the other is directed along the radius. This would provide the necessary centripetal force i.e., $F = \frac{mv^2}{r} = \frac{Gmm}{(r+r)^2}$ (or) $v = \sqrt{\frac{Gm}{4r}}$

8. If a man weighs 60 kg on the earth, how far must he go from the centre of the earth so that he weighs 30 kg ? (Radius of earth = 6400 km)

A. $\frac{W_1}{W_2} = \frac{(R_2)^2}{(R_1)^2}$

W_1 = Weight of the object on the surface of the earth.

W_2 = Weight of the object far above the earth.

R_1 = Radius of the earth.

R_2 = Distance of the object far above the earth.

$$\frac{60}{30} = \frac{(R_2)^2}{(6400)^2}$$

(or) $2 \times (6400)^2 = (R_2)^2$

(or) $R_2 = \sqrt{2} \times 6400$

$R_2 = 1.414 \times 6400 = 9049.6$ km.

9. A ball is thrown vertically upwards from the top of a building of height 24.5 m with an initial velocity 19.6 m s^{-1}. Taking g = 9.8 m s^{-2}, calculate :

i) The height to which it will rise before returning to the ground,

A. Given, u = 19.6 m s^{-1} (upwards), height of building x = 24.5 m.

At the highest point, v = 0.

For upward journey,from relation $v^2 = u^2 - 2gh$

$0 = u^2 - 2gh$ or $h = \frac{u^2}{2g} = \frac{(19.6)^2}{2 \times 9.8} = 19.6m$

ii) The velocity with which it will strike the ground

A. While returning from the highest point, u = 0, total height travelled = 19.6 + 24.5 = 44.1 m. Let v be the velocity with which it strikes the ground. Then from relation $v^2 = u^2 + 2gh$.

$v^2 = 0 + 2 \times 9.8 \times 44.1$.

$\therefore\ v = \sqrt{2 \times 9.8 \times 44.1} = 29.4\, ms^{-1}$

iii) The total time of journey.

A. If the ball takes time t_1 to go the highest point from the top of building, then for upward journey from relation v = u – gt.

$0 = 19.6 - 9.8\ t_1$ or $t_1 = \frac{19.6}{9.8} = 2s$

Now for downward journey from the highest point, if the ball takes time t_2 to reach the ground, then u = 0, v = 29.4 ms^{-1}.

From relation v = u + gt.

$29.4 = 0 + 9.8\ t_2$

$\therefore\ t_2 = \frac{29.4}{9.8} = 3s$

Hence total time of journey $t = t_1 + t_2$

$= 2 + 3 = 5$ s.

10. Suppose a planet exists whose mass and radius both are half of those of earth. Calculate the accelertion due to gravity on the surface of this planet.

A. Take the value of 'g' on the surface of earth as 9.8 m/s^2

$g = G\frac{M}{R^2}$

$g_M = 9.8\, m/s^2$, $g_P = ?$

$M_M = 6 \times 10^{24}\, kg$, $M_P = 3 \times 10^{24}\, kg$

$R_H = 6.4 \times 10^6\, m$, $R_P = 3.2 \times 10^6\, m$

$\frac{g_P}{g_M} = \frac{GM_P}{R_P^2} \times \frac{R_M^2}{GM_m}$

$= \frac{3 \times 10^{24} \times 6.4 \times 6.4 \times 10^{12}}{3.2 \times 3.2 \times 10^{12} \times 6 \times 10^{24}}$

$g_p = 2(g_M) = 2(9.8)$

= 19.6 m/s^2

11. A rocket is launched to travel vertically upwards with a constant velocity of 20 m/s. After travelling for 35 s the rocket develops a snag and its fuel supply is cut off. The rocket then travels like a free body. What is the total height achieved by it ? After what time of its launch will it come back to the earth ?

A. Upward distance covered by the rocket in first 35s $= ut = 20 \times 35 = 700$ m

When the fuel supply is cut-off : u = 20 m/s, g = –10 m/s^2, v = 0, therefore

$v^2 - u^2 = 2gs$ or $0 - (20)^2 = 2 \times (-10) \times s$

or $s = \frac{400}{20} = 20\,\text{m}$

Total height achieved = 700 + 20 = 720 m.

Also $t = \frac{v-u}{g} = \frac{0-20}{-10} = 2\,s$

For downward motion of the rocket : u = 0, S = 720 m, g = 10 m/s^2

As $S = ut + \frac{1}{2}gt^2$

$\therefore \quad 720 = 0 + \frac{1}{2} \times (10) t^2$ or $t^2 = 144$

or $t = \sqrt{144} = 12\,s$

Total time taken = 35 + 2 + 12 = 49s.

12. A helicopter is on a mission to drop food for people standing on a boat. It is at a height of 20 m and moving with a steady horizontal velocity of 2 m/s when it spots the nearest end of the boat immediately below it. It drops the packets then. If the length of the boat is 5 m, will the people in the boat receive the packets ?

A. For vertical motion of the food packet : u = 0, s = –20 m, g = –10 m/s^2

As $S = ut + \frac{1}{2}gt^2$

$\therefore \quad -20 = 0 - \frac{1}{2} \times 10 \times t^2$ or $t^2 = 4$

or $t = 2$ s

For horizontal motion of the food packet : Velocity = 2 m/s. t = 2 s

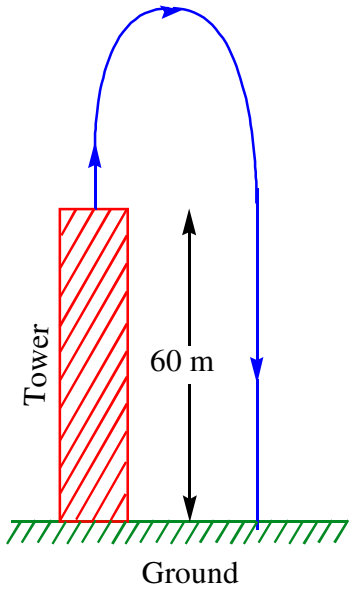
$S = vt = 2 \times 2 = 4$ m

This distance is less than the length (5m) of the boat. Yes, the people in the boat will receive the food packets.

13. A man is standing at the top of a 60 m high tower. He throws a ball vertically upwards with a velocity of 20 m/s. After what time will the ball pass him going downward ? How long after its release will the ball reach the ground ? (Take g = 10 m/s²)

A. i) When the ball passes the man, net displacement = 0 or S = 0

Also u = + 20 m/s, g = –10 m/s²



As $S = ut + \frac{1}{2}gt^2$

$\therefore \quad 0 = 20 \times t + \frac{1}{2} \times (-10) t^2$

or t = 20/5 = 4s.

ii) Here, S = –60 m (Downward displacement)

As $S = ut + \frac{1}{2}gt^2$

$\therefore \quad -60 = 20 \times t - \frac{1}{2} \times 10 \times t^2$

or $-12 = 4t - t^2$

or $t^2 - 4t - 12 = 0$ or $(t - 6)(t + 2) = 0$

$\therefore$ t = 6 or –2

But time cannot be negative

$\therefore$ t = 6 s.

Total time taken by the body to reach the ground after release = 10 s.

III. COMPETENCY - FORMULATE, ANALYZE, EVALUATE AND CREATE

1. Distinguish between mass and weight of an object, How does weight of an object change on moving from equator to poles ? when can the weight of an object be zero.

A. From relation w = mg and $g = \frac{GM}{R^2}$

Weight depends on 'g' and 'g' depends radius of the earth (R).

We know that the shape of earth is elliptical due to this shape. It is bulging at the equator (greater Radius) flatened at the poles (minimum radius at the poles)

$$w \propto g \propto \frac{1}{R}$$

So weight of an object increases on moving from equator to poles 'g' value at the centre of the earth is zero. So weight is also zero.

2. List in tabular form any three differences between 'g' and G.

A.

Universal gravitational constant (G)	Acceleration due to gravity (g)
1) Gravitational force between two bodies of unit mass separable by a unit distance is known as universal gravitational constant.	1) Acceleration produced in a freely falling body under the action of gravitational pull of earth is known as acceleration due to gravity.
2) Value of G is same at every point on earth.	2) Value of 'g' is different at different points on the earth.
3) Value of 'G' does not change with height or depth.	3) 'g' value decrease with increasing depth or height above the surface of earth.

3. Does centre of gravity of an object exist at a point where there is no mass of the object ? Explain with an example ?

A. It is possible to have centre of gravity of an object exist at a point where there is no mass of the object When we find the center of gravity of ring we observe that it is present at the center of the ring where there is no mass.

4. We know that heavier body experience greater gravitational force than lighter bodies ? then why they do not fall faster than a lighter body ?

A. 1) Gravitational attraction of the earth on any object is proportional to its mass (m)

2) But the acceleration due to gravity of the earth is $g = \frac{GM}{R^2}$ where M is the mass of the earth and R is the radius of the earth.

3) It means g is independent of the mass of the body.

4) Hence all bodies fall on the earth with the same acceleration whatever may be their mass.

5. Why are multistage rockets used to launch space crafts?

A. Multistage rockets have greater efficiency than single stage rockets. As the multistage rocket proceeds in its path, each used up stage will detach itself, igniting the next stage, there by reducing the weight of the rocket. So, the rocket at the final stage will have much less weight leading to efficiency in working.

6. Why is Newton's law of gravitation called the universal law ?

A. This is because the law of gravitation holds good for any pair of bodies in the universe, whether the bodies are big or small, or whether they are celestial or terrestrial.

7. Suppose gravity of earth suddenly becomes zero, then in which direction will the moon begin to move, it no other celestial body affects it?

A. The moon will begin to move in a straight line in the direction in which it was moving at that instant because the circular motion of moon is due to centripetal force provided by the gravitational force of earth.

8. Does an object contain the same quantity of matter on the earth, on the moon and in the outer space?

A. Yes, an object contains the same quantity of matter whether it is on the earth, on the moon or in the outer space.

9. Why do all objects hollow or solid, big or small, fall at the same rate?

A. Since the acceleration due to gravity does not depend on the mass of an object, all objects hollow or solid, big or small fall at the same rate in the absence of air resistance.

10. In what direction does the thrust act ?

A Normal to a surface

QUICK REVIEW

➢ **Gravitation :** The phenomenon of attraction between different bodies in the universe, is called gravitation.

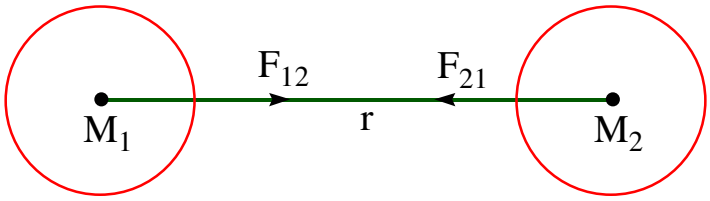
- The force of attraction is called force of gravitation.
- Attraction between two bodies having masses of same order, is called gravitation and the force is called force of gravitation.
- Attraction between planet (earth) or its satellite on a body, having masses of widely different order is called gravity and the force is called force of gravity.
- Force of gravitation is an invisible force.

➢ **Universal Law of Gravitation : (Newton's Law of Gravitation)**

The law states that, "Every body in the universe attracts every other body with a force which is directly proportional to product of their masses and inversely proportional to the square of the distance between their centres".

The force is mutual and direction of force is along the line - joining the centres of the two bodies.

Let two bodies of masses M_1 and M_2 lie with centres at a distance 'r' apart.



The force of attraction between them is given by.

$$F \propto M_1 M_2$$

$$F \propto \frac{1}{r^2} \text{ [Inverse square law]}$$

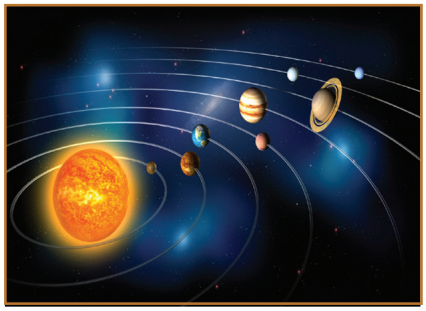
Combining $\boxed{F = \frac{GM_1M_2}{r^2}}$

- G is constant of proportionality $\boxed{G = \frac{Fr^2}{M_1M_2}}$. It is called universal gravitational constant.
- $G = 6.67 \times 10^{-11}\ Nm^2\ kg^{-2}$
- SI unit of G is $Nm^2\ kg^{-2}$, C.G.S unit of G is dyne $cm^2\ g^{-2}$

➢ **Importance of Newton's Law of Gravitation :**

This law explains successfully several unconnected phenomena. Some of these are

- All planets revolve around the sun due to the gravitational force between the sun and the planet.
- Tides in oceans are due to the gravitational force between the moon and water in oceans.
- Atmosphere (gases) of earth is possible due to the gravitational force of earth .
- Artificial satellite move around the earth due to the gravitational force between the earth and the satellite.
- Snow fall and rain fall is possible due to the gravitational pull of earth.
- Our stay on earth is possible due to the gravitational force between the earth and sun i.e., gravitational force keeps us bound to the earth.


➢ **Free Fall :** The falling of a body from a height towards the earth only under the gravitational force of earth (with no other forces acting on it) is called free fall and such a body is called "freely falling body". We know that when a freely falling body moves downward its velocity increases at a constant rate hence a uniform acceleration is produced in the object.

➢ **Acceleration due to Gravity :** The uniform acceleration produced in a freely falling body due to the gravitational force of the earth (force of gravity) is called acceleration due to gravity.

- **Expression of 'g' :** If we drop a body (say, a stone) of mass 'm' from a distance 'R' from the centre of the earth of mass M, then the force exerted by the earth on the body is given by universal law of gravitation as :

$$F = \frac{GMm}{R^2} \qquad \text{..... (1)}$$

This force exerted by the earth produce acceleration in the stone due to which the stone moves downwards.

So Force = Mass × Acceleration

F = m × a

Acceleration of stone, $a = \frac{F}{m}$ ..... (2)

From (1) and (2) $a = \frac{GMm}{R^2} \times \frac{1}{m}$

We already know, acceleration produced by the earth is known as acceleration due to gravity and represented by the symbol 'g'.

$\therefore$ Acceleration due to gravity, $\boxed{g = \frac{G \times M}{R^2}}$

From above equation we can say that, the acceleration produced in the freely falling bodies is the same for all the bodies and it does not depend on the mass of the falling body.

➢ **Calculation of 'g' :**

we know that

Mass of earth M = 6×10^{24} kg

Radius of earth, R = 6.4×10^{6} m

Gravitational constant, G = 6.67×10^{-11} $Nm^2 kg^{-2}$

Putting these values in $g = \frac{GM}{R^2}$

$$g = \frac{6.67 \times 10^{-11} \times 6 \times 10^{24}}{\left(6.4 \times 10^{6}\right)^2}$$

$$\boxed{g = 9.8\ m/s^2}$$

Thus, the value of acceleration due to gravity is 9.8 m/s^2. But some times, to make the calculation easy, the value of 'g' is taken as round figure 10 m/s^2.

Note : Acceleration due to gravity acts in the direction of the line joining the body to the centre of the earth.

➢ **Equations of Motion For Freely Falling Bodies :** We know that freely falling bodies fall with uniformly accelerated motion (Constant acceleration) All the equations of motion derived earlier for bodies under uniform acceleration can be applied to the motion of freely falling bodies.

For freely falling bodies 'a' is replaced by 'g' and the displacement (or) distance is replaced by the height (h) and initial velocity u = 0.

S.No.	General equations of motion	Equations of motion for freely falling bodies
i)	$v = u + at$	$v = gt$
ii)	$S = ut + \frac{1}{2} at^2$	$h = \frac{1}{2} gt^2$
iii)	$v^2 - u^2 = 2aS$	$v^2 = 2gh \Rightarrow v = \sqrt{2gh}$

➢ **Mass :** The mass of a body is the quantity of matter (or material) contained in it.

- Mass is a scalar quantity.
- Mass of a body can never be zero.
- Mass of a body is constant and does not change from place to place.
- Mass of a body is measured by Beam Balance.
- It is represented by symbol 'm'
- The SI unit of mass is kilogram (kg).
- Mass of a body is a measure of inertia of the body and it also known as inertial mass.

➢ **Weight :** The force with which a body is attracted towards the earth, is called the weight of the body.

- It is a vector quantity having direction towards the centre of the earth. By definition,

  Force = weight $\boxed{w = m \times g}$ [g = Acceleration due to gravity]

- As w = mg, the weight of a body varies from place to place, due to variation in the value of 'g'.
- At the centre of the earth, weight of a body is zero [where g = 0].
- Weight is measured by spring balance.
- SI unit of weight is newton (N).
- The weight of 1kg mass w = m × g = 9.8 kg m/s^2 or 9.8 N

➢ **Weight of an object on the moon :**

Suppose the mass of the moon is M^1 and its radius is R^1. Consider an object of mass m placed on its surface. The weight of the object on the moon is $w^1 = \frac{GM^1m}{R^{1^2}}$.

The weight of the same object placed on the earth's surface will be

$$w = \frac{GM_e \times m}{R_e^2}$$

Thus $\frac{w^1}{w} = \frac{M^1}{M_e} \times \frac{R_e^2}{R'^2}$

Now, mass of the earth $M_e = 6 \times 10^{24}$ kg , mass of the moon M' = 7.4×10^{22} kg, radius of the earth R_e = 6, 400 km , radius of the moon R' = 1, 740 km

Putting these values in the above equation.

$$\frac{w^1}{w} = \frac{7.4 \times 10^{22} kg}{6 \times 10^{24} kg} \times \left(\frac{6400 km}{1740 km}\right)^2 \approx \frac{1}{6}$$

Thus $\boxed{w^1 = \frac{w}{6}}$

i.e, Weight of an object on the moon is about $\frac{1}{6}th$ of its weight on the surface of the earth.

Note : As w = mg

$$\frac{w^1}{w} = \frac{m'g'}{mg_e}$$

$$\frac{1}{6} = \frac{g'}{g_e}$$

$$\Rightarrow \boxed{g' = \frac{1}{6}g_e}$$

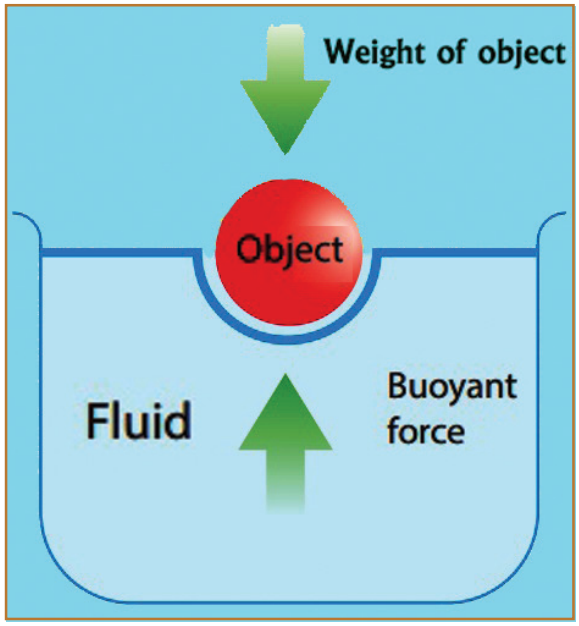
Weight on moon $w' = \frac{1}{6} \times$ weight on earth and acceleration on moon

$$g' = \frac{1}{6} \times [\text{Acceleration due to gravity}].$$

- **Thrust :** The total force exerted by a body on any surface in contact with it is called thrust.
- **Pressure :** The thrust acting per unit area of the surface of a body is called pressure.

$$\text{Pressure} = \frac{\text{Thrust}}{\text{Area}}$$

The SI unit of pressure is N/m^2 or pascal (Pa)



- **Buoyancy :** The upward force acting on a body immersed in a fluid is called upthrust or force of buoyancy and the phenomenon is called buoyancy.
- **Archimedes principle :** It states that when a body is immersed fully or partially in a fluid, it experiences an upward thrust equal to the weight of the fluid displaced by it.
- **Density :** The density of a substance is mass per unit volume.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

The S.I unit of density is kg/m^3.

ANALYSE AND APPLY

1. The phenomenon of attraction between different bodies in the universe is called _____
2. Snow fall and rain fall is possible due to _____ of earth.
3. The thrust acting per unit area of the surface of a body is called _____.
4. When a body is immersed fully or partially in a fluid, it experiences an upward force that is equal to _____ .
5. The weight of freely falling body is zero (T/F)
6. Gravitational force between two bodies may be negative (T/F)
7. The weight of an object on the moon is $\frac{1^{th}}{6}$ of its weight on the surface of the earth (T/F)
8.

	Column - I		Column - II
i)	Universal gravitational constant	p)	Pascal
ii)	Acceleration due to gravity	q)	newton
iii)	Thrust	r)	kg/m^3
iv)	Pressure	s)	$9.8\ m/s^2$
v)	Density	t)	$6.67 \times 10^{-11}\ Nm^2/kg^2$

9.

	Mass		Weight
i)	Mass is scalar	i)	Weight is _____ .
ii)	Mass of an object never _____	ii)	Weight of an object can be zero
iii)	Mass can be measured by _____ balance.	iii)	Weight can be measured by _____ balance.
iv)	SI unit of mass is _____.	iv)	Gravitational unit of weight is _____.

OBJECTIVE EXERCISE

Multiple choice questions :

1. The weight of a certain object is 6 kg on the earth. what will be the weight of the same object on the moon? [ ]
   a) 2 kg b) 1.5 kg c) 1 kg d) 2.5 kg
2. How many newtons are there in 1kg – wt ? [ ]
   a) 980 N b) 9.8 N c) 0.98 N d) 0.098 N
3. What is the SI unit of weight ? [ ]
   a) dyne b) kg – wt c) N d) both 'b' and 'c'
4. Relation between pressure (P), force (F) and area of cross-section (A) is [ ]
   a) p = FA b) $F = \frac{p}{A}$ c) $P = \frac{F}{A}$ d) $P = \frac{F}{A^2}$

5. According to the principle of floatation [ ]
a) Weight of the liquid displaced = weight of the floating body
b) Weight of the liquid > weight of the floating body
c) Weight of the liquid displaced < weight of the floating body
d) None of these

6. The equation $F = \frac{G m_1 m_2}{r^2}$ is valid for [ ]
a) rectangular bodies b) circular bodies c) elliptical bodies d) spherical bodies

7. Where a body is thrown up, the force of gravity is [ ]
a) In the upward direction b) In the downward direction
c) Zero d) In the horizontal direction

8. A coin and feather are dropped together in a vacuum [ ]
a) The coin will reach the ground first b) The feather will reach the ground first
c) Both the bodies will reach the ground together d) The feather will not fall down

9. The mass of the object remains the ———— [ ]
a) increases in everywhere b) same in everywhere
c) decreases in everywhere d) None of the above

10. Value of gravitational constant is [ ]
a) 6.67×10^{11} Nm^2 / kg^2 b) 6.67×10^{-11} Nm^2 / kg^2
c) 11.67×10^{-11} Nm^2/kg^2 d) none

11. The upward pressure exerted by a static liquid is explained by which of the following principle [ ]
a) Pascal's law b) Achimedes principle c) Bernoulli's theorem d) Newton's law

12. Pressure exerted by a liquid is [ ]
a) Directly proportional to its density b) Inversely proportional to its density
c) Independent of its density d) Directly proportional to the area of cross - section

13. The force of attraction between the molecules of the same medium is called [ ]
a) Adhesive force b) Cohesive force c) Magnetic force d) Electric force

14. The force of attraction between the molecules of different medium is called [ ]
a) Adhesive force b) Cohesive force c) Magnetic force d) Electric force

15. At a given depth liquid exerts [ ]
a) Same pressure in all directions b) No pressure at all
c) More pressure in a particular direction d) Less pressure in a particular direction

16. Choose the correct option [ ]
a) 1 $kg/m^3 = 10^{-3} g/cm^3$ b) 1 $kg/m^3 = 10^3 g/cm^3$ c) 1 $kg/m^3 = 10^{-5} g/cm^3$ d) 1 $kg/m^3 = 10^5 g/cm^3$

17. Choose the correct option [ ]
a) Thrust at a point is a vector quantity
b) Pressure at a point is a scalar quantity
c) Thrust at a point is a scalar quantity
d) both a and b

18. When a liquid is taken in a container, choose the correct option [ ]
a) The pressure inside the liquid increasing with depth
b) The pressure inside a liquid at depth h is given by $P = P_0 + \rho gh$
c) The pressure inside the liquid at a constant depth is constant
d) All the above

19. When an object floats on the surface of a liquid, [ ]
a) It displaces a weight of liquid equal to its own weight.
b) It displaces a weight of liquid less than its own weight
c) It displaces a weight of liquid greater than its own weight
d) None of these

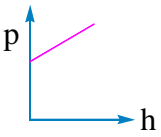
Assertion & Reason Tpye Questions :

a) Both A and R are correct and R is the correct explanation of A
b) Both A and R are correct but R is not the correct explanation of A
c) A is correct, R is incorrect d) A is incorrect, R is correct

20. **Assertion (A) :** A solid body of density half that of water, falls from a height of 10 m and then enters into water. The depth to which it will go in water is 10 m. [ ]
Reason (R) : Inside water a body experience buoyant force .

21. **Assertion (A) :** A man sitting in a boat which is floating on a pond . If the man drinks some water from the pond, the level of water in the pond decreases. [ ]
Reason (R) : According to Archimede's principle the weight of displaced fluid by body is equal to weight of the body .

22. **Assertion (A) :** Graph between pressure 'p' and depth 'h' below the surface of a liquid open to atmosphere as shown [ ]
Reason (R) : Static pressure increases linearly with depth.



23. **Assertion (A) :** Gravitational force between two charged particles is negligibly compared to the electrical force. [ ]
Reason (R) : The electrical force is experienced by charged particles only.

24. **Assertion (A) :** The universal gravitational constant is same as acceleration due to gravity.
Reason (R) : Gravitational constant and acceleration due to gravity have different dimensional formula. [ ]

OLYMPIAD CORNER

1. Mass of the planet is M. If the mass of the planet reduced to $1/8^{th}$ of the original without change in density. Then what is the new value of acceleration due to gravity of the planet ? [ ]

   a) 5g b) $\frac{g}{2}$ c) 3g d) $\frac{g}{3}$

2. We get less sugar for 5 kg weight at [ ]

   a) Equator b) Centre of the earth c) Pole d) None of the given three

3. If g_p is the acceleration due to gravity at the poles and g_e that at equator then. [ ]

   a) $g_p < g_e$ b) $g_p > g_e$ c) $g_p = g_e$ d) $g_e = 0$

4. The correct relation between gravitational mass and inertial mass is [ ]

   a) inertial mass > gravitational mass b) inertial mass = gravitational mass

   c) inertial mass < gravitational mass d) none

5. The value of G depends on [ ]

   a) the mass of bodies b) the medium between the bodies

   c) the temperature of bodies d) It is an independent constant

6. The atmosphere is held to the earth by [ ]

   a) the rotation of the earth b) the attraction of the sun

   c) the gravity d) All

7. $F = \frac{Gm_1m_2}{r^2}$ this force is always [ ]

   a) Attractive b) Repulsive c) Both a and b d) None of these

8. When we try to push empty plastic bottle in to the water by our hand we feel [ ]

   a) Upward thrust increases as we try to push the bottle deep in to a liquid

   b) Upward thrust decreases as we try to push the bottle deep in to a liquid

   c) Upward thrust remains same as we try to push the bottle deep in to a liquid

   d) None of these

9. Archimedes made the wonderful observation that when a body is kept immersed in a liquid

   a) It appears to lose some of its weight. [ ]

   b) The apparent loss of weight of the immersed body is equal to the weight of the liquid displaced.

   c) The apparent loss of weight of the immersed body is greater than the weight of the liquid displaced.

   d) Both a and b

10. Our body is not crushed by the atmospheric pressure because [ ]

    a) Our blood exerts a pressure which is slightly more than the atmospheric pressure

    b) Our blood exerts a pressure which is equal to the atmospheric pressure.

    c) Our blood exerts a pressure which is slightly less than the atmospheric pressure.

    d) None of these

11. A man can easily float on the water of the Dead Sea without sinking because [ ]
a) Density of human body with empty lungs is 1.07 g/cc while lungs filled with air is 1.00 g/cc
b) In the Dead Sea, the density of water is 1.16 g/cc
c) In the Dead Sea, the density of water is 1.06 g/cc
d) Both a and b

12. Various applications of Archimedes Principle are [ ]
a) Designing of submarines and ships
b) Lactometers which are used to determine the purity of sample of milk.
c) Hydrometers which are used to determine the density of liquids
d) all the above

13. How much force acting perpendicular to a surface having area of 0.5 m^2 will produce a pressure of 500 pa ? [ ]
a) 150 N b) 350 N c) 175 N d) 250 N

14. Atmospheric pressure is 1.01×10^5 pascal. How much force is exerted by air on the inside of a window plane that is 40 cm × 100 cm? [ ]
a) 2.04×10^5 N b) 4.04×10^4N c) 4.04×10^6N d) 2.04×10^4

15. An object weight 10 N when measured on the surface of the earth what would be its weight when measured on the surface of the moon ? [ ]
a) 1.77 N b) 1.67 N c) 2.77 N d) 2.67 N

16. The mass of a boy is 50 kg what will be his weight on the earth. What is his weight on moon ? ($g = 10\ m/s^2$) [ ]
a) 30.33 N b) 88.33 N c) 83.33 N d) 33.83 N

17. An object weight 10 N in air. When immersed fully in water, it weights only 8 N The weight of the liquid displaced by the object will be. [ ]
a) 2 N b) 8 N c) 10 N d) 12 N

18. A ball is thrown up and attains maximum height of 20 m. Calculate its initial speed. ($g = 10\ ms^{-1}$)
a) 19.7 m/s b) 20 m/s c) 25 m/s d) 35m/s [ ]

19. Two bodies of mass 10 kg each are separated by 1 metre. The force of attraction between them is
a) 6.67×10^{-9}N b) 6.67×10^5N c) 6.67×10^{-5}N d) 6.67×10^9N [ ]

20. A stone thrown upwards attains maximum height of 19.6m. Find the velocity with it was thrown
a) 20 m/s b) 18.36 m/s c) 19.6 m/s d) 20.6 m/s [ ]

4 WORK AND ENERGY

WISE UP

- **Newton's First Law :** "If the vector sum of all the forces acting on a particle is zero, then and only then the particle remains unaccelerated" (i.e.,remains at rest or moves with constant velocity)
- **Momentum ($\vec{p}$) :** It is the property of a body which depends on it's mass and velocity and is given by the product of mass and velocity.

  Momentum = mass x velocity

  $$\Rightarrow \vec{p} = m\vec{v}$$
- **Relation between momentum (p) and kinetic energy (K).**

  $$p^2 = 2mK \Rightarrow p = \sqrt{2mK}$$
- **Newton's second law :** "The rate of change of momentum is directly proportional to force applied and acts along the direction of applied force".

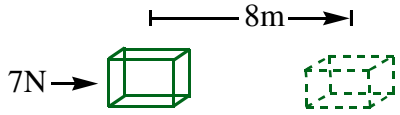
  $$\vec{F} = m\vec{a}$$
- **Force :** Force is a physical quantity which changes (or) tries to change the state of rest (or) uniform motion of a body.
  - SI Unit : newton (N), Dimensional Formula: $[M^1 L^1 T^{-2}]$.
- **Gravitational force :** Any two bodies attract each other by virtue of their masses. The force of attraction between two point masses is directly proportional to the product of masses and inversely proportional to the square of distance between them.
  - If m_1, m_2 are the masses of two particles and r is the distance between them, then Gravitational force $F = \frac{Gm_1m_2}{r^2}$
  - Where G is universal gravitational constant
  - $G = 6.67 \times 10^{-11}\ Nm^2kg^{-2}$
- **Dot Product :** If the product of two vectors produces a scalar, such product is called scalar product (or) dot product.
  - The dot product of two vectors is the product of the magnitudes of the vectors and the cosine of angle between them.
  - If $\vec{a}$ and $\vec{b}$ are the two vectors with an angle 'θ' between them, then their dot product is denoted by $\vec{a}.\vec{b}$ given by $\vec{a}.\vec{b} = ab\cos\theta$
- **Examples of dot product**
  - Work done $W = \vec{F}.\vec{S} = FS\cos\theta$,

    where F is the force and S is displacement due to the application of force.
  - Instantaneous power $P = \vec{F}.\vec{V} = FV\cos\theta$,

    where F is force and V is instantaneous velocity.

NCERT TEXTUAL QUESTIONS

1. A force of 7N acts on an object. The displacement is say 8m in the direction of the force. Let us take it that the force acts on the object through the displacement. What is the work done in this case ? **(Applying)**



A. Work done = Force × Displacement
= 7 N × 8 m = 56 Nm = 56 J

2. When do we say that work is done ? **(Understanding)**

A. Work is said to be done whenever a force acts on a body and the body moves in the direction of the force

3. Write an expression for the work done when a force is acting on an object in the direction of its displacement. **(Understanding)**

A. Work done = Force × Displacement.

4. Define 1 J of work **(Understanding)**

A. One joule of work is said to be done when a force of one newton displaces a body through a distance of 1m in its own direction.

5. A pair of bullocks exerts a force of 140 N on a plough. The field of being ploughed is 15m long, How much work is done in ploughing the length of the field ? **(Applying)**

A. Here, Force (F) = 140 N, Displacement (S) = 15m

Work done (W) = FS

= 140 × 15 = 2100 Nm = 2100 J

6. What is the kinetic energy of an object ? **(Understanding)**

A. The energy possessed by an object by virtue of its motion is called its kinetic energy.

7. Write an expression for the kinetic energy of an object ? **(Understanding)**

A. Kinetic energy = $\frac{1}{2}mv^2$

8. The kinetic energy of an object of mass 'm' moving with a velocity of 5m/s is 25J. What will be its kinetic energy when its velocity is doubled ? What will be its kinetic energy when its velocity is increased three times ? **(Applying)**

A. Initial kinetic energy = 25J

$E_k \propto v^2$

$$\frac{E_1}{E_2}=\left(\frac{v_1}{v_2}\right)^2 \Rightarrow \frac{25}{E_2}=\left(\frac{5}{10}\right)^2 \Rightarrow \frac{25}{E_2}=\frac{25}{100} \Rightarrow E_2=100J$$

$$\frac{E_1}{E_2}=\left(\frac{v_1}{v_2}\right)^2 \Rightarrow \frac{25}{E_2}=\left(\frac{5}{15}\right)^2 \Rightarrow \frac{25}{E_2}=\left(\frac{25}{225}\right) \Rightarrow E_2=225\ J$$

9. What is power ? **(Understanding)**

A. Power is defined as the rate of doing work or the rate of transfer of energy.

10. Define 1 watt of power. **(Understanding)**

A. The power of an agent is one watt if it does work at the rate of 1 joule per second

11. A lamp consumes 1000J of electrical energy in 10s. What is its power? **(Applying)**

A. $P = \frac{W}{t}$

$$P = \frac{1000J}{10s} = 100\ Js^{-1} = 100\ W$$

12. Define average power. **(Understanding)**

A. It is be defined as the total energy consumed by it is divided by the total time taken

$$\text{Average power} = \frac{\text{Total energy consumed}}{\text{Total time taken}}$$

NCERT TEXTUAL EXERCISES QUESTIONS

1. Look at the activities listed below. Reason out whether or not work is done in the light of your understanding of the term 'work' : **(Understanding)**

i) Suma is swimming in a pond

ii) A donkey is carrying a load on its back

iii) A wind mill is lifting water from a well

iv) A green plant is carrying out photosynthesis

v) An engine is pulling a train

vi) Food grains are getting dried in the sun

vii) A sailboat is moving due to wind energy

A. i) Yes, Suma is doing work by pushing water in the backward direction.

ii) No, because the force exerted by donkey in the upward direction is perpendicular to the horizontal displacement of the load.

iii) Yes, work is done in lifting water against the force of gravity

iv) No, because the leaves of plants remain at rest during photosynthesis

v) Yes, engine is doing work in pulling the train. Both the applied force and displacement are in same direction

vi) No, because food grains remain at rest.

vii) Yes, work is done by the wind in moving the sailboat

2. An object thrown at a certain angle to the ground moves in a curved path & falls back to the ground. The initial and the final points of the path of the object lie on the same horizontal line. What is the work done by the force of gravity on the object ? (Understanding)

A. Zero, This is because the net displacement of the object is in the horizontal direction, while the force of gravity acts in the vertical downward direction.

3. A battery lights a bulb. Describe the energy changes involved in the process . (Analyzing and Evaluating)

A. First the battery converts chemical energy into electrical energy. Then the bulb converts this electrical energy into heat and light.

4. Certain force acting on a 20kg mass changes its velocity from 5m/s to 2m/s. Calculate the work done by the force. (Applying)

A. Here, m = 20 kg ; u = 5 m/s ; v = 2 m/s

$$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 = \frac{1}{2}m(v^2 - u^2)$$

$$= \frac{1}{2} \times 20 \times (2^2 - 5^2)$$

$$= \frac{1}{2} \times 20(4 - 25)$$

$$= -10 \times 21$$

$$W = -210 \text{ J}$$

The negative sign indicates the retarding nature of force.

5. A mass of 10kg is at a point A on a table. It is moved the work done on a table. It is moved to a point B. If the line joining A & B is horizontal what is the work done on the object by the gravitational force ? Explain your answer . (Applying)

A. Displacement AB is horizontal. Force of gravitation acts vertically downwards. That is, force acts perpendicular to displacement.

$\therefore$ $W = FS \cos 90^\circ$

$\Rightarrow$ $W = 0$

6. The potential energy of a freely falling object decreases progressively. Does this violate the law of conservation of energy ? Why ? (Creating)

A. No, The law of conservation of energy is not violated the loss in potential energy appears as an equal gain in kinetic energy of the object.

7. What are the various energy transformation that occur when you are riding a bicycle ? (Creating)

A. We use our muscular energy in pulling the bicycle. So, our muscular energy changes into kinetic energy. A part of the muscular energy is used in doing work against friction of the road. This part of the muscular energy changes into heat

8. Does the transfer of the energy take place when you push a huge rock with all your might and fail to move it ? Where is the energy you spend going ? (Analyzing and Evaluating)

A. Yes, we transfer our muscular energy while pushing rock. This energy is entirely spent in doing work against friction between the rock and ground.

9. A certain household has consumed 250 units of energy during a month. How much energy is this in joules ? (Applying)

A. 1 unit of energy = 1 kWh = 3.6×10^6 J

$\therefore$ 250 units of energy = $250 \times 3.6 \times 10^6$ J = 9×10^8 J

10. An object of mass 40 kg is raised to a height of 5m above the ground. What is its potential energy? If the object is allowed to fall, find its kinetic energy when it is half way down ? (Applying)

A. m = 40 kg ; g = 10 m/s^2 ; h = 5m

Potential energy of the object at a height of 5m,

E_P = mgh = $40 \times 10 \times 5 = 2000$ J.

When the object is half - way down (S = 2.5m),

let the velocity be v. Then $v^2 - u^2 = 2gh$

$v^2 - 0 = 2 \times 10 \times 2.5$

or $v^2 = 50$

$\therefore$ Kinetic energy of the object,

$$E_k = \frac{1}{2} mv^2 = \frac{1}{2} \times 40 \times 50$$

E_k = 1000 J

11. What is the work done by the force of gravity on a satellite moving round the earth ? justify your answer. (Understanding)

A. Zero. When the satellite moves around the earth, the force of gravity acts on it along the radius of its orbit, while its direction of motion is along the tangent to the orbit at any point. Thus, force acts perpendicular to displacement. Hence, the work done on the satellite is zero.

12. Can there be displacement of an object in the absence of any force acting on it ? Think Discuss this question with your friends and teacher. (Creating)

A. Yes, for example, rain drops fall on the earth while the net force on them is zero.

13. A person holds a bundle of hay over his head for 30 minutes and gets tired. Has he done some work or not ? Justify your answer. (Analyzing and Evaluating)

A. No, The bundle of hay remains stationary i.e displacement is zero. so, the work done is also zero.

14. An electric heater is rated 1500 W. How much energy does it use in 10 hours ? (Applying)

A. P = 1500W ; t = 10h

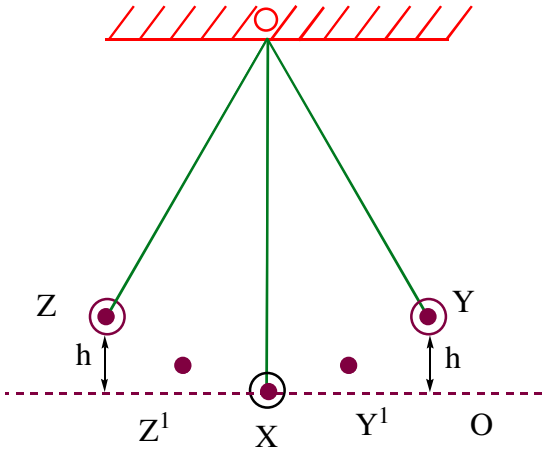
energy used = p × t

= 1500 W × 10 h

= 15000 W × 1h = 15 kWh

15. Illustrate the law of conservation of energy by discussing the energy changes which occur when we draw a pendulum bob to one side and allow it to oscillate. Why does the bob eventually come to rest? What happens to its energy eventually? Is it a violation of the law of conservation of energy?

A. In simple pendulum, when the bob is at mean position i.e., at 'X' potential energy P.E. is zero. When it is displaced from X to Y it gains P.E. If Y is at a distance h vertically above 'X' , the bob has a P.E. at Y gets converted into K.E. at X.



i.e., $\frac{1}{2}mv^2 = mgh \Rightarrow v = \sqrt{2gh}$ where v is the speed of the bob at X.

Due to this speed, the bob overshoots X and reaches Z^1 and at Z^1 its energy is partly kinetic and partly potential but the sum of K.E and P.E is the same as K.E at X. When it reaches Z whole of its energy become P.E. Thus the bob possess constant mechanical energy (sum of KE and PE) always at all the points on it's path. The bob eventually comes to rest due to its motion against the gravity then its kinetic energy gets converted into potential energy. These is no loss of energy and the total energy remains constant. Hence the law of conservation of energy is not being violated.

16. An object of mass 'm' is moving with a constant velocity v. How much work should be done on the object in order to bring object to rest? (Applying)

A. Change in K.E of the object $= \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

$$= \frac{1}{2}m(0)^2 - \frac{1}{2}mv^2 = -\frac{1}{2}mv^2$$

17. Calculate the work required to be done to stop a car of 1500 kg moving at a velocity of 60 km/h? (Applying)

A. m = 1500 kg

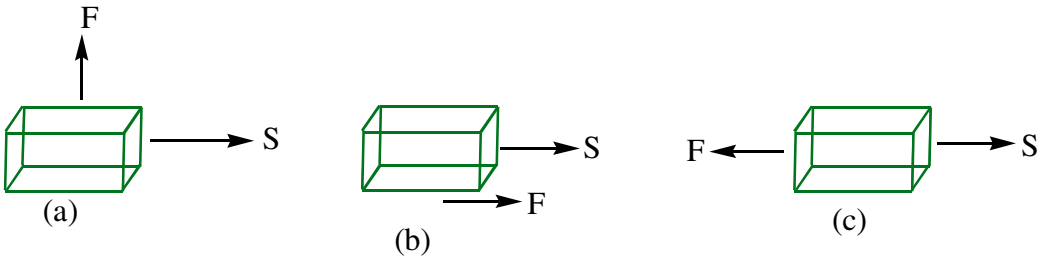
u = 60 km/h

$$= \frac{60 \times 1000}{3600s} = \frac{50}{3} m/s, \quad v = 0 \text{ m/s}$$

Work done to stop the car $W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

$$= \frac{1}{2}(0)^2 - \frac{1}{2} \times 1500 \times \left(\frac{50}{3}\right)^2 = -208333.3 \text{ J}$$

18. In each of the following a force F is acting on an object of mass m. The direction of displacement is from west to east shown by the longer arrow observe the diagrams carefully and state whether the work done by the force F is negative, positive or zero. (Applying)



A. a) Here force is perpendicular to displacement

$W = FS \cos 90^\circ = 0 \rightarrow$ Zero work

b) Here force and displacement is in same direction.

$W = FS \cos 0^\circ = FS \rightarrow$ Positive work

c) Here F and S are in opposite direction

$W = FS \cos 180^\circ = FS(-1) = -FS \rightarrow$ Negative work

19. Soni says that the acceleration in an object could be zero even when several forces are acting on it. Do you agree with her ? Why ? (Creating)

A. Yes, the acceleration of the object would be zero when the several forces acting on the object add up to give a zero resultant force.

$$a = \frac{F}{m} = \frac{0}{m} = 0$$

20. Find the energy in joules consumed in 10 hours by four devices of power 500 W each. (Applying)

A. $P = 500\ W = \frac{500}{1000}\ kW = 0.5kW$

$t = 10h$

Each consumed by four devices $= 4P \times t = 4 \times 0.5\ kW \times 10h = 20\ kWh.$

21. A freely falling object eventually stops on reaching the ground. What happenes to its kinetic energy?

A. When a body falls freely, its potential energy converts into kinetic energy due increasing its velocity. The body come to rest when it strikes the ground then its kinetic energy gets converted into heat energy, sound energy etc.,

TEXT BOOK SOLVED PROBLEMS

1. A force of 5 N is acting on an object. The object is displaced through 2 m in the direction of the force find the work done. (Applying)

A. If the force acts on the object it moves all through the displacement

then work done is $W = FS \Rightarrow 5\ N \times 2m = 10\ N\ m$ or $10\ J$.

2. A porter lifts a luggage of 15 kg from the ground and puts it on his head 1.5 m above the ground. Calculate the work done by him on the luggage. (Applying)

A. Mass of luggage, m = 15 kg and displacement, S = 1.5 m.

Work done, $W = F \times S = mg \times S$

$= 15 \text{ kg} \times 10 \text{ ms}^{-2} \times 1.5 \text{ m}$

$= 225 \text{ kg ms}^{-2} \text{ m}$

$= 225 \text{ N m} = 225 \text{ J}$

Work done is 225 J.

3. An object of mass 15 kg is moving with a uniform velocity of $4ms^{-1}$. What is the kinetic energy possessed by the object ? (Applying)

A. Mass of the object, m = 15 kg, velocity of the object, $v = 4 \text{ ms}^{-1}$.

$$E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 15kg \times 4ms^{-1} \times 4ms^{-1} = 120J$$

The kinetic energy of the object is 120 J.

4. What is the work to be done to increase the velocity of a car from 30 kmh^{-1} to 60 kmh^{-1} if the mass of the car is 1500 kg ? (Applying)

A. Mass of the car, m = 1500 kg,

Initial velocity of car, u = 30 kmh^{-1}

$$= \frac{30 \times 1000m}{60 \times 60s} = \frac{25}{3} \text{ ms}^{-1}.$$

Similarly, the final velocity of the car, $v = 60 \text{ kmh}^{-1} = \frac{50}{3} \text{ ms}^{-1}$

Therefore, the initial kinetic energy of the car,

$$K_i = \frac{1}{2}mu^2 = \frac{1}{2} \times 1500 \text{ kg} \times \left(\frac{25}{3}\right)^2 (\text{ms}^{-1})^2$$

$$= \frac{156250}{3} \text{ J}.$$

The final kinetic energy of the car,

$$K_f = \frac{1}{2} \times 1500 \ kg \times \left(\frac{50}{3}\right)^2 (ms^{-1})^2 = \frac{625000}{3} J.$$

Thus, the work done = change in kientic energy

$= K_f - K_i = 156250 \text{ J}.$

5. Find the energy possessed by an object of mass 10 kg when it is at a height of 6 m above the ground. Given, g = 9.8 ms^{-2} **(Applying)**

A. Mass of the object, m = 10 kg, displacement (height), h = 6 m
Acceleration due to gravity, g = 9.8 ms^{-2}.
Potential energy = mgh
= 10 kg × 9.8 ms^{-2} × 6m = 588 J.
The potental energy is 588 J.

6. An object of mass 12 kg is at a certain height above the ground. If the potential energy of the object is 480 J, find the height at which the object is with respect to the ground. Given, g = 10 ms^{-2} **(Applying)**

A. Mass of the object, m = 12 kg,
Potential energy, E_p = 480 J.

$E_p = mgh$

480 J = 12 kg × 10 ms^{-2} × h

$$h = \frac{480}{120} = 4m.$$

The object is at the height of 4m.

7. Two girls, each of weight 400 N climb up a rope through a height of 8 m. We name of the girls A and the other B. Girl A takes 20 s while B takes 50 s to accomplish this task. What is the power expended by each girl ? **(Applying)**

A. i) Power expended by girl A :
Weight of the girl, mg = 400 N
Displacement (height), h = 8 m
Time taken, t = 20 s
Power, P = work done / time taken

$$= \frac{mgh}{t}$$

$$= \frac{400N \times 8m}{20s} = 160W$$

ii) Power expended by girl B :
Weight of the girl, mg = 400 N
Displacement (height), h = 8 m

Power, $P = \frac{mgh}{t}$

$$= \frac{400N \times 8m}{50s} = 64W$$

Power expended by girl A is 160 W.
Power expended by girl B is 64 W.

8. A boy of mass 50 kg runs up a staircase of 45 steps in 9 s. If the height of each step is 15 cm, find his power. Take g = 10 ms^{-2} **(Applying)**

A. weight of the boy, mg = 50 kg × 10 ms^{-2} = 500 N

height of the staircase, h = 45 × 15 / 100 m = 6.75 m

Time taken to climb, t = 9 s

Power, P = work done / time taken

$$= \frac{mgh}{t} = \frac{500N \times 6.75m}{9s} = 375 \text{ W.}$$

Power is 375 W.

ADDITIONAL QUESTIONS

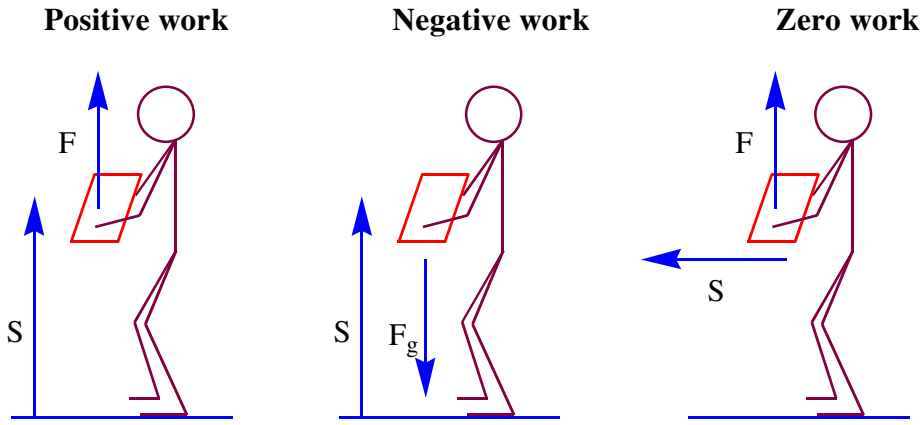
I. COMPETENCY - DEMONSTRATE KNOWLEDGE AND UNDERSTANDING

1. Define : i) Positive work ii) Negative work iii) Zero work

A. i) **Positive work :** If force and displacement are along the same direction the work done is said to be positive work.

ii) **Negative work :** If force and displacement are acting in the opposite direction the work done is said to be negative work.

iii) **Zero work :** If force and displacement are perpendicular to each other the work done is said to be zero work.



2. Give some examples of potential energy due to position.

A. i) Arrow from the bent bow.

ii) Water stored in the reservoir of a dam.

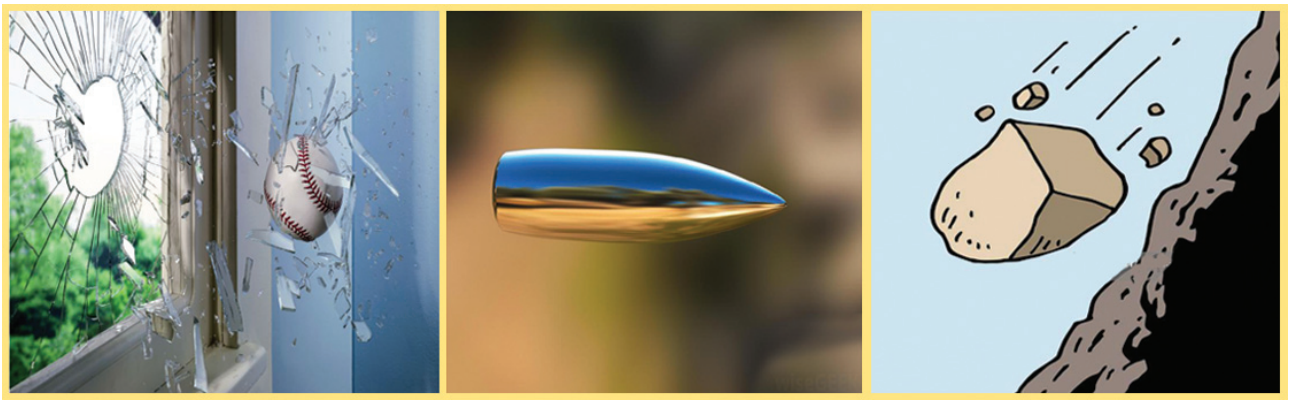
iii) Compressed spring.

3. Give some examples of kinetic energy due to position.

A. i) Fast moving objects.

ii) Bullet fired from the gun.

iii) Rock rolling down from the hill.



4. Name the practical unit of power used in daily life.

A. Horse power

5. State the law of conservation of energy

A. The energy in a system can neither be created nor destroyed. It may be transformed from one form to another, but total energy of the system remains constant.

6. Water stored in Bhakra Dam is used to produce electric power. Explain various types of energy transformation taking place in the process.

A. As the water falls from a height, the potential energy of water stored in the dam is converted into kinetic energy of running water which gets converted into rotational kinetic energy of the turbine that ultimately changes into electrical energy of the generator.

7. Define potential energy and write it's expression ?

A. The energy possessed by a body by virtue of its position is called potential energy.

PE = mgh

8. Name the different types in potential energy

A. i) Gravitational potential energy

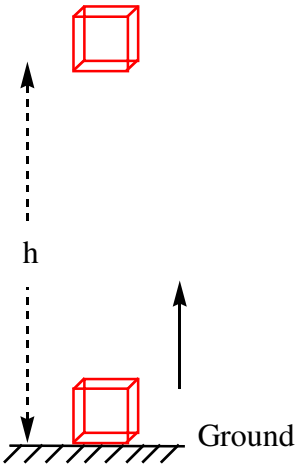
ii) Elastic potential energy

iii) Electric potential energy

9. Name the instrument which transforms electrical energy into mechanical energy ?

A. Electric motor

10. Derive the formula for potential energy of an object at a height h.



A. Consider an object of mass, m. Let it be raised through a height, h from the ground. The minimum force required to raise the object is equal to the weight of the object, mg. The object gains energy equal to the work done on it. Let the work done on the object against gravity be W.

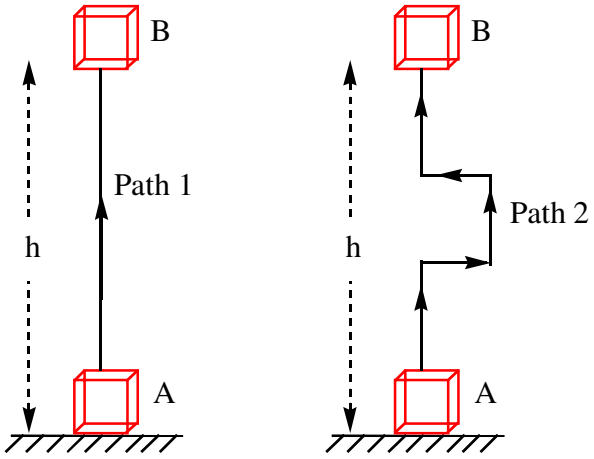
That is, work done, W = force × displacement

= mg × h = mgh

Since work done on the object is equal to mgh, an energy equal to mgh units is gained by the object. This is the potential energy (PE) of the object. PE = mgh

11. Show that the workdone to lift a body to height 'h' is depends on height, but not path followed to lift the body to height.

A. It is useful to note that the work done by gravity depends on the difference in vertical heights of the initial and final positions of the object and not on the path along which the object is moved. Figure. Shows a case where a block is raised from position A to B by taking two different paths. Let the height AB = *h*. In both the situations the work done on the object is *mgh*.



12. Why does the driver speeds up his vehicle when he moves up a hill ?

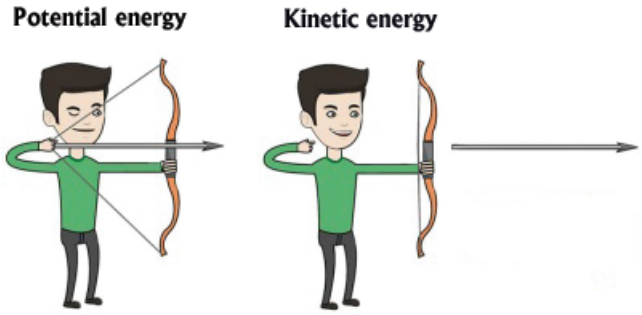
A. As the vehicle moves up the hill, its kinetic energy gradually changes into potential energy, so to move it up further, it needs more of kinetic energy which is obtained by increasing its speed.

13. If a body moves along a frictionless path, its energy remains always the same. Why ?

A. While moving along a frictionless path, a body does not experience any resting force. So no work is done by the body its energy remains constant.

14. When an arrow is shot, where from the arrow will acquire its kinetic energy ?

A. A stretched bow possesses potential energy due to the change in its shape. To shoot an arrow, the bow is released. The potential energy of the bow is converted into the kinetic energy of the arrow



15. What change should be effected in the velocity of a body to maintain the same kinetic energy if its mass is increased four times?

A. K.E = $\frac{1}{2}$ mv^2. If mass is increased to four times, the velocity must be reduced to half to maintain the same kinetic energy.

16. Derive the formula of kinetic energy of an object of mass 'm' moving with an uniform acceleration'a'

A. Let u and v be the initial and final velocities and also a and s be the uniform acceleration and displacement respectively, then from equation of motion,

$v^2 = u^2 + 2as$

$\Rightarrow \quad S = \frac{v^2 - u^2}{2a}$ ..... (i)

Work done by the force, F is

$W = F \times S = ma \times \left(\frac{v^2 - u^2}{2a}\right) (\because F = ma)$

$\Rightarrow \quad W = \frac{1}{2} m (v^2 - u^2)$

When the body is starting from the rest position, then u = 0

Thus, $W = \frac{1}{2} m (v^2 - u^2)$ ..... (ii)

But work done is equal to the change in kinetic energy of an object.

So, the kinetic energy acquired by a body of mass m and moving with a uniform velocity, v is given by $E_k = \frac{1}{2} mv^2$

17. Why does a Hack saw blede becomes warm when it is used to cut a log of wood ?

A. A Hack saw blede becomes warm when it is used to cut a log of wood because it possess kinetic energy due to its motion. This kinetic energy is converted into heat energy due to friction at the point of contact on the log of wood.

18. What kind of energy transformation takes place in thermal power station?

A. Heat energy is converted into electrical energy.

II. COMPETENCY - APPLICATION OF KNOWLEDGE/CONCEPTS

1. A truck driver loads some oil drums into a truck by lifting them directly. Each drum has a mass of 80 kg and the platform of the truck is at a height of 0.8 m above the ground.

i) What force is needed to lift a drum into the truck ?

A. Given : m = 80 kg, h = 0.8 m, g = 10 ms^{-2}

Force needed to lift a drum

= Force of gravity on drum

= mg = 80 × 10 = 800 N

ii) How much energy is used up in lifting a drum ?

A. Energy used up in lifting a drum

= gravitational potential energy

= mgh

= 80 × 10 × 0.8 = 640 J

iii) After the truck is loaded, the driver drives off. List the major energy changes that take place in moving the truck.

A. In moving the truck, the chemical energy of the fuel (diesel) changes into the mechanical (kinetic) energy.

iv) The driver stops the truck at the factory gate. What happens to the kinetic energy of the truck ?
Take g = 10 ms^{-2}.

A. On stopping the truck, the kinetic energy of the truck changes into the heat and sound energies.

2. A ball of mass 10 g falls from a height of 5 m. It rebounds from the ground to a height of 4 m. Find:

i) The initial potential energy of the ball,

A. Given : $m = 10g = \frac{10}{1000} kg = 0.01kg$,

h = 5 m, g = 9.8 ms^{-2}, h = 4 m.

Initial potential energy of the ball = mgh = 0.01 × 9.8 × 5 = 0.49 J

ii) The kinetic energy of the ball just before striking the ground,

A. Kinetic energy of the ball just before striking the ground = Initial potential energy of the ball = 0.49 J

iii) The kinetic energy of the ball after striking the ground, and

A. Kinetic energy of the ball after striking the ground = Potential energy of ball at the highest point after rebound.

= mgh = 0.01 × 9.8 × 4 = 0.392 J

iv) The loss in kinetic energy on striking the ground.
Take g = 9.8 ms^{-2}

A. Loss in kinetic energy on striking the ground = Initial kientic energy – Final kinetic energy = 0.49 J – 0.392 J = 0.098 J

3. A body of 5 kg initially at rest is subjected to a force of 20 N. Calculate the kinetic energy acquired by the body at the end of 10 seconds.

A. Here,
m = 5 kg, u = 0, F = 20 N, t = 10s

Acceleration, $a = \frac{F}{m} = \frac{20}{5} = 4ms^{-2}$

Velocity after 10 second $v = u + at = 0 + (4 \times 10) = 40\ ms^{-1}$

Thus, kinetic energy $= \frac{1}{2} mv^2 = \frac{1}{2} \times 5 \times (40)^2 = 4000$ J

4. a) The potential energy of a freely falling object decreases progressively. What happens to its (i) kinetic energy, (ii) total mechanical energy ? State the law on which your answer is based.

b) A household consumes 1 kWh of energy per day. How much energy is this in joules ?

A. a) i) The potential energy of a freely falling object decreases progressively, because a part of the potential energy changes into kinetic energy continuously. Thus, kinetic energy increases progressively.

ii) Total mechanical energy = Potential energy + Kinetic energy = Constant

This relation is based on the law of conservation of energy

b) 1 kWh = 1000 W × 1h

= 1000 W × 60 × 60 s

= 3600000 joule

= 3.6×10^6 joule

= 3.6 M J

5. What is meant by term power ? A boy pulls a bucket of water of mass 10 kg from a 5m deep well in 10 seconds. Calculate the power developed by the boy. ($g = 10ms^{-2}$).

A. The rate of doing work is called power

Mass of water (m) = 10 kg.

Displacement (S) = 5m

∴ Force exerted by the boy (F) = mg

= 10 × 10 = 100 N.

∴ Work done by the boy (W) = F × S

= 100 × 5 = 500 J

∴ Time for doing work (t) = 10s

$\therefore$ Power of the boy (P)

$$P = \frac{W}{t} = \frac{500J}{10s} = 50 \text{ W.}$$

6. Define the term potential energy. Write an expression for potential energy of an object of mass 'm' at a height 'h' above the ground. What is the potential energy possessed by an object of mass 1 kg kept at a height of 1m. ($g = 10\ ms^{-2}$)

A. **Potential energy :** The energy possessed by a body on account of its position or configuration is called potential energy.

Potential energy = mgh

Here, $m = 1$ kg, $h = 1$ m, $g = 10\ ms^{-2}$

Potential energy = $mgh = 1 \times 10 \times 1 = 10J$

7. Two women Shanti and Kamala each of mass 50 kg and 60 kg respectively climb up through a height of 10m. Shanti takes 20 s while Kamala takes 40 s to reach. Calculate the difference in the power expended by Shanti and Kamala, (Assuming $g = 10\ ms^{-2}$)

A. Power expended by Shanti,

$$P_1 = \frac{mgh}{t_1} = \frac{50 \times 10 \times 10}{20} = 250 \text{ watt}$$

Power expended by Kamala,

$$P_2 = \frac{mgh}{t_2} = \frac{60 \times 10 \times 10}{40} = 150 \text{ watt}$$

$\therefore$ $P_1 - P_2 = 250 - 150 = 100$ watt.

8. a) Define Power ?

b) In an office a tube light of 40W, a fan of 75 W and a cooler of 150 W have been installed, If all these appliances are used for 8 hours a day.

A. a) Power is defined as the rate of doing work,

$$P = \frac{W}{t}$$

b) E = (40 + 75 + 150) W × 8 h per day = 2.120 Wh = 7632 J

9. a) State and define SI unit of power.

b) A person carrying 10 bricks each of mass 2.5 kg on his head moves to a height 20 metres in 50 seconds. Calculate the power spent in carrying bricks of the person. ($g = 10\ m/s^2$)

A. a) S.I. Unit of power is watt (W). Amount of work done by 1J of energy in 1 second is called 1 watt.

b) Total mass (m) = 10 × 2.5 kg = 25 kg.
Time (t) = 50s , $g = 10 ms^{-2}$
Force exerted by person = mg = 12 kg × $10 ms^{-2}$ = 250 N

Work done = Force × Displacement = 250 N × 20m = 5000 J

$$\therefore \quad \text{Power} = \frac{\text{Work done}}{\text{Time}} = \frac{5000J}{50\,s} = 100W$$

10. A man is instructed to carry a package from the base came to B to submit at A of a hill at a height of 1200 metres. The man weight 800 N and the package weights 200 N. if g = 10m/s^2
i) How much work does man do against gravity?
ii) What is the potential energy of the package at A if it is assumed to be zero at B ?

A. i) 12×10^5 J
ii) 2.4×10^5 J

III. COMPETENCY - FORMULATE, ANALYZE, EVALUATE AND CREATE

1. A coolie is walking on a railway platform with 20kg load on his head. What is the amount of work done by him ? Justify your answer.

A. Work done is zero. Here W = FS cos 90º= 0

2. The speed of a car increases four times. What is the increase in its kinetic energy ?

A. Its K.E increases 16 times because K.E $\propto v^2$

3. Can a body have momentum, without possessing energy ?

A. No, if a body has momentum, it will be in motion and will certainly possess kinetic energy.

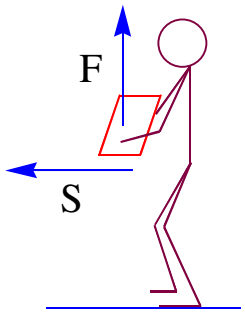
4. Can the kinetic energy of an object be negative ?

A. No, both m and v^2 are always positive.

5. Can potential energy of an object be negaitve ?

A. Yes, P.E is negative when forces involved are attractive.

Zero work



6. How much work is done when we push on immovable stone ? Justify

A. As the distance moved by immovable stone in the direction of force is zero, work done is zero.

7. How is energy stored in a watch ?

A. In winding a watch, work is done is compressing the spring which is stored in the form of potential energy. As the spring expands, it does work and moves the hands of the watch.

8. State the energy transformations taking place in the following cases :
a) When brakes are applied to a speeding vehicle.
b) When an arrow is released from a stretched bow.
c) When some one speaks in front of a microphone.
d) When a tuning fork is hit against a rubber pad
e) When the coil of motor moves in a magnetic field.

A. a) When brakes are applied to a speeding vehicle, then kinetic energy of the vehicle is converted into heat energy.

b) When an arrow is released from a stretched bow, then potential energy of the bow is converted into kinetic energy of the arrow.

c) When someone speaks infront of a microphone then sound energy is converted into electrical enregy.
d) When tuning fork is hit against a rubber pad then kinetic energy is converted into sound energy.
e) When the coil of a motor moves in a magnetic field then mechanical energy is converted into electric energy.

9. A boy tries to push a truck parked on the roadside. The truck does not move at all. Another boy pushes a bicycle. The bicycle moves through a certain distance. In which case was the work done more on the truck or on the bicycle? Give a reason to support your answer.

A. More work is done on the bicycle. This is because the bicycle moves through a certain distance on applying force (push); no work is done on the truck because it doesnot move at all on applying force (push).

10. The work done by a force acting obliquely is given by the formula : $W = F \cos \theta \times S$. What will happen to the workdone if angle θ between the direction of force and motion of the body is increased gradually? will it increase, decrease or remain constant ?

A. Decrease.

11. In a tug of war, one team is slowly giving way to the other. What work is being done by whom?

A. The work done by the winning team is equal to the product of resultant force applied by the two teams and the displacement suffered by the loosing team.

12. The head of nail becomes warm when it is hammered into a plank of wood. Explain the series of energy transformations that have taken place.

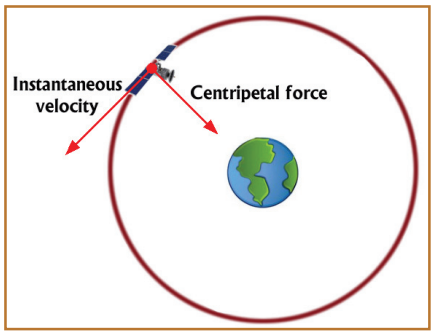
A. The kinetic energy of the moving hammer is converted into heat energy when it strikes the head of the nail. Due to this heat energy, the temperature of head of the nail increases.

13. How do you say that a lift delivers more power in taking a man up than that delivered by the man climbing stairs through the same height?

A. As the lift takes, less time, so it delivers more power.

14. How much work is done by the gravitational force of earth acting on a satellite moving around in a circular path ? Give reason for your answer.

A. Zero; Because the gravitational force acts along the radius of circular path, at right angle (90°) to the motion of satellite.



15. A man X goes to the top of a building by a vertical spiral stair case. Another man Y of the same mass goes to the top of the same building by a slantive ladder. Which of the two does more work against gravity and why ?

A. Both the men, X and Y, do equal amount of work against gravity because irrespective of whether they reach the top of building by using a spiral stair case or slantive ladder the vertical distance moved by them against gravity is the same

16. What should be the angle between the direction of force and the direction of motion of a body so that the work done is zero ?

A. 90º.

17. In which of the following case the work done by a force will be maximum: when the angle between the direction of force and direction of motion is 0º or 90º ?

A. When the angle between the direction of force and direction of motion is 0º.

18. When a ball is thrown vertically up wards, Its velocity goes on decreasing. What happens to its potential energy as its velocity becomes zero ?

A. Potential energy becomes the maximum.

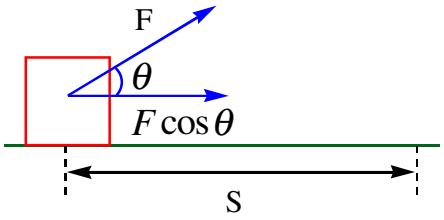
19. When a ball is thrown inside a moving bus, does its kinetic energy depend on the speed of the bus ? Explain.

A. Yes, the kinetic energy of a ball thrown inside a moving bus depends on the speed of the bus. This is because the speed of bus adds up to the speed with which the ball is thrown inside the moving bus.

QUICK REVIEW

➢ **Work :** Work is said to be done whenever a force acts on a body and the body moves in the direction of the force

- Work done = Force × Displacement.
- When F acts along the direction of motion, W = FS.
- When F makes an angle θ with displacement S of the body W = FS $\cos\theta$
- For maximum work $\theta = 0° \Rightarrow W = FS$
- For minimum work $\theta = 90° \Rightarrow W = 0$
- Work done on an object by a force would be zero if the displacement of the object is zero.
- The S.I unit of work is joule.



➢ **Joule :** One joule of work is said to be done, whenever a force of one newton displaces a body through a distance of 1m in its own direction 1J = 1Nm

➢ **Energy :** Energy of a body is defined as its capacity to do work. It is a scalar quantity.

- The S.I unit of energy is joule.
- The different forms of energy are Mechanical energy, Sound energy, Heat energy, Light energy, Chemical energy, Nuclear energy, Electric energy, Magnetic energy, Solar energy etc.

➢ **Kinetic Energy :** The energy possessed by a body by virtue of its motion is called its kinetic energy

$$\text{K.E} = \frac{1}{2}mv^2.$$

Ex : Bullet fired from the gun

- Relation between work done and kinetic energy.
  Work done = Change in K.E

➢ **Potential Energy :** The energy possessed by a body by virtue of its position is called potential energy.

- The gravitational potential energy of an object at a point above the ground is defined as the work done in raising it from the ground to that point against gravity PE = mgh

➢ **Law of conservation of energy :** Energy can neither be created nor destroyed. It can be transformed from one form to another. The total energy before and after the transformation always remains constant.

➢ **Power :** The rate of doing work is called power.

- $\text{Power} = \frac{\text{Work}}{\text{Time}}$
- The S.I unit of power is watt.

➢ **Watt :** If one joule of work done in one second then the power is said to be one watt.

- $1 \text{ watt} = \frac{1 \text{ J}}{1 \text{ s}} = 1 \text{ Js}^{-1}$
- 1 kilowatt = 1000 W
- Horse power is one of the practical unit of power.
  1 horse power = 746 W.
- The work, power and energy are all scalar quantities.

ANALYSE AND APPLY

1. When the angle between force and displacement is 90° then work done is said to be _____
2. The energy possessed by a body due to its position is called _____ energy.
3. A freely falling body can possess _____ and _____ energies.
4. Energy can neither be created nor destroyed (T/F)
5. Power is defined as rate of transfer of energy (T/F)
6. A vertically projected body can possess equal kinetic energy and potential energy at all points (T/F)
7.

Column - I		Column - II	
i)	Negative workdone	p)	θ between F and S is 0°
ii)	Positive work done	q)	θ between F and S is 90°
iii)	Zero work done	r)	θ between F and S is 180

8.

Column - I		Column - II	
i)	Work	p)	joule
ii)	Kinetic energy	q)	watt
iii)	Potential energy	r)	house power
iv)	Power	s)	scalar

9.

	Column - I		Column - II
i)	1 watt	p)	10^7 erg
ii)	1 horse power	q)	1 J/s
iii)	1 joule	r)	746 W

10.

	Column - I		Column - II
i)	Work	p)	$\frac{W}{t}$
ii)	Kinetic energy	q)	mgh
iii)	Potential energy	r)	$\frac{1}{2}mv^2$
iv)	Power	s)	FS

OBJECTIVE EXERCISE

Multiple choice questions :

1. When a body falls freely towards the earth, then its total energy : [ ]
   a) Increases b) Decreases
   c) Remains constant d) First increases and then decreases.

2. A car is accelerated on a levelled road and attains a velocity 4 times of its initial velocity. In this process the potential energy of the car : [ ]
   a) Does not change b) Becomes twice to that of initial
   c) Becomes 4 times that of initial d) Becomes 16 times that of initial.

3. In case of negative work, the angle between the force and displacement is : [ ]
   a) 0° b) 45° c) 90° d) 180°

4. An iron sphere of mass 10 kg has the same diameter as an aluminium sphere of mass is 3.5 kg. Both the spheres are dropped simultaneously form a tower. When they are 10 m above the ground, they have the same : [ ]
   a) Acceleration b) Momentum c) Potential energy d) Kinetic energy

5. A girl is carrying a school bag of 3 kg mass on her back and moves 200 m on a levelled road. The work done against the gravitational force will be ($g = 10\ ms^{-2}$) : [ ]
   a) 6×10^3 J b) 6 J c) 0.6J d) Zero

6. Which one of the following is not the unit of energy ? [ ]
   a) joule b) newton metre c) kilowatt d) kilowatt hour

7. The work done on an object does not depend upon the : [ ]
   a) Displacement b) Force applied
   c) Angle between force and displacement d) Initial velocity of the object

8. Water stored in a dam possesses : [ ]
   a) No energy b) Electrical energy
   c) Kinetic energy d) Gravitational potential energy

9. A body is falling from a height h. After it has fallen to a height $\frac{h}{2}$ it will possess : [ ]

a) Only potential energy b) Only kinetic energy
c) Half potential and half kinetic energy d) More kinetic and less potential energy

10. A coolie carries a load of 500 N to a distance of 100 m. The work done by him is : [ ]

a) 5 J b) 50,000 J c) 0 J d) $\frac{1}{5}$ J

11. S.I unit of work is : [ ]

a) kilogram b) gram c) joule d) newton

12. If 1 newton of force displaces a body by 1m, the work done is : [ ]

a) 10 joules b) 5 joule c) 1 joule d) Depends on time

13. A 1 kg mass has a kinetic energy of 1 joule when its speed is : [ ]

a) 0.45 ms^{-1} b) 10s^{-1} c) 1.4 ms^{-1} d) 4.4 ms^{-1}

14. One joule work is said to be done when : [ ]

a) a force of 1 N displaces a body by 1 cm b) a force of 1 N displaces a body by 1 m
c) a force of 1 dyne displaces a body by 1 cm d) a force of 1 dyne displaces a body by 1m.

15. The work done in one complete revolution of the earth around the sun is equal to : [ ]

a) Zero b) gravitation force X circumference of earth's orbit
c) gravitational force X diameter of earth's orbit d) Centripetal force X radius of the earth

16. In the oscillations of a simple pendulum, the sum of the P.E. and K.E. is : [ ]

a) Zero b) Infinite c) Constant d) Maximmum

17. When a force retards the motion of a body, the work done is : [ ]

a) Positive b) Zero c) negative d) Uncertain

18. An object of mass 5 kg falls from a height of 5 m above the ground. The loss of potential energy of the mass is : [ ]

a) 250 J b) 25 J c) 2.5 J d) 50 J

19. An object of mass 1 kg has a potential energy of 1 joule relative to the ground when it is at a height of:

a) 0.102 m b) 1 m c) 9.8 m d) 32 m [ ]

20. Work done is a ———— quantity [ ]

a) Vector b) Scalar c) Tensar d) None of these

21. The Dimensional formula of work is [ ]

a) $[M^1 L^2 T^2]$ b) $[M^0 L^2 T^{-2}]$ c) $[M^1 L^2 T^{-2}]$ d) $[M^1L^2T^2]$

22. Work done by a constant force can be ———— [ ]

a) Positive b) Negative c) Zero d) all the above

23. A work done in unit time is called ———— [ ]

a) Force b) Energy c) Power d) None

24. The SI unit of power is ———————— [ ]
a) watt b) Joule c) Joule/ sec^2 d) Watt - s

25. The work done by centrifugal force on a body in circular motion. ———— [ ]
a) Positive b) Negative c) zero d) all of these

Assertion & Reason Tpye Questions :

a) Both A and R are correct and R is the correct explanation of A
b) Both A and R are correct but R is not the correct explanation of A
c) A is correct, R is incorrect d) A is incorrect, R is correct

26. **Assertion (A) :** The work done by gravitational force during a round trip is always zero.
Reason (R) : No force is required to move a body in its round trip. [ ]

27. **Assertion (A) :** A light body and heavy body have same momentum. Then they also have same kinetic energy. [ ]
Reason (R) : Kinetic energy depend on mass of the body .

28. **Assertion (A) :** A spring has potential energy, both when it is compressed or stretched [ ]
Reason (R) : In compressing or stretching, work done by the spring against the restoring force.

29. **Assertion (A) :** Work done by friction on a body sliding down an inclined plane is positive
Reason (R) : Work done is greater then zero, if angle between force and displacement is acute or both are in same direction. [ ]

30. **Assertion (A) :** Water at the foot of the water fall is always at different temperature from that at the top. [ ]
Reason (R) : The potential energy of water at the top is converted into heat energy during falling.

OLYMPIAD CORNER

1. In which of the following case the person involved in action spends some energy and doing work
a) A man is lifting cement bags from the ground and keeping them one by one in a lorry [ ]
b) A girl is pulling a toy car on the ground and the trolley moves a distance.
c) A boy is trying to push a huge rock lying in a play ground but unable to move the rock.
d) Both a and b

2. In which of the following cases there is a change in the position of the object on which work has been done [ ]
a) A man is lifting cement bags from the ground and keeping them one by one in a lorry
b) A boy is trying to push a huge rock lying in a play ground but unable to move the rock.
c) A porter is waiting on the platform of a railway station with luggage on his head
d) None of these

3. In which of the following cases the person is doing the work and spends some energy, but there is no change in the position of the object on which work has been done [ ]
a) A man is lifting cement bags from the ground and keeping them one by one in a lorry
b) A boy is trying to push a huge rock lying in a play ground but unable to move the rock.
c) A porter is waiting on the platform of a railway station with luggage on his head
d) both b and c

4. Porter standing on the railway platform with luggage on his head [ ]
a) spends a lot of energy against the gravitational force acting on the luggage
b) does lot of work though there is no change in the position of luggage.
c) does zero work because there is no change in the position of luggage.
d) both a and c

5. According to the scientific concept of the work, to say that work has been done the conditions needed
a) A force should act on the object [ ]
b) The object must be displaced or there must be change in the position of the object.
c) no force should act on the object d) both a and b

6. Suppose that a constant force (F) acts on an object and object is moved through a distance (s) along the direction of the force (F) work done is equal to [ ]
a) the product of the force (F) and the distance (s) moved
b) $W = F \times S$ when force and distance must be in same direction
c) when force is not along the direction of motion then W = component of force in that direction ofmotion × distance moved
d) both b and c

7. The body on which the work has been done looses energy [ ]
a) If work has negative value b) If work has positive value
c) If work has zero value d) none of these

8. A metal ball kept in a ceramic plate is raised to a certain height from the plate and allowed to fall on it then [ ]
a) the metal ball does no work when it rests on the surface of the plate
b) it is able to do some work when it is raised to a height
c) it is unable to do some work when it is raised to a height d) both a and b

9. The capacity of doing work by an object on another object depends [ ]
a) on position and state of the object which is doing work
b) on the acquired energy through different means
c) on the energy transfer between the object doing the work and the object on which work has been done
d) all the above

10. When we compress the spring with palm and release it after few seconds then [ ]
a) it gains some energy and may even jump from the table b) it do not gain energy
c) it gains some energy and remains without movement d) all the above

11. Choose the correct option [ ]
a) The object which does work looses energy b) The object on which work has been done gains energy
c) The object which does work gains energy d) both a and b

12. Illustrations of kinetic energy are [ ]
a) a fast moving cricket ball hits the wickets, and make the wickets to tumble
b) the swinging bat in the hands of a batsman hits the ball it reaches the boundary
c) a fast moving bullet pieces the target d) all the above

13. Total work done on a particle is equal to the change in its kinetic energy [ ]
a) always b) Only if the forces acting on it by the net force
c) Only if gravitational force acts on it d) Only if elastic force acts on it

14. Illustrations of potential energy are [ ]
a) When we stretch the string, of bow it throws the arrow into air with a great speed
b) When we wind the key of toy car then the car moves on the ground when released
c) If the hammer is raised to a certain height and then allowed to fall on the nail then nail is pushed some distance into the plank. d) all the above

15. When a ball is dropped from a height [ ]
a) its gravitational potential energy decreases
b) its kinetic energy increases
c) it possesses both potential energy as well as kinetic energy during its fall to the ground
d) all the above

16. The quantity which tells that how fast or how slow work is done [ ]
a) potential energy b) kinetic energy c) power d) all the above

17. If a body of mass 10kg is pushed horizontally by a horizontal force of 5 newton, then the work done by gravity is [ ]
a) 50 joule b) 5 joule c) 98 joule d) 0

18. A child pulls a toy car of mass 100g by applying a force of 100N at an angle of 60°. If toy car is displaced by 5 meter in the horizontal direction, then the work done is [ ]
a) 2.5 J b) 0.25 J c) 25 J d) 250 J

19. Power of a centripetal force in a circular motion is ———————— [ ]
a) Constant b) Infinity c) Zero d) Both b & c

20. An object of mass (m) is at rest on a smooth horizontal plane and displaced through a distance 's' by a force (F) acting upon it then [ ]
a) The work done on the object by the net force $W = F_{net}\ s = F\ s$
b) The work done on the object cause a change in its velocity from 'u' to 'v'
c) the work done on the object is equal to $W = \frac{1}{2} m (v^2 - u^2)$
d) all the above

5 SOUND

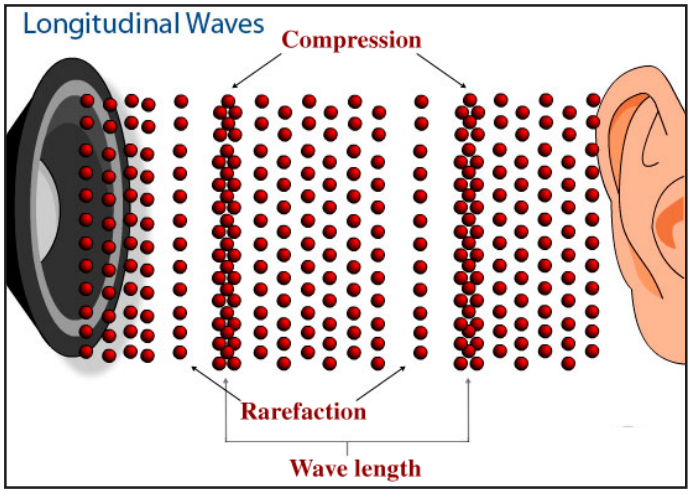
WISE UP

- **Sound :** Sound is a form of energy, which causes the sensation of hearing.
  - Sound helps us to communicate with one another.
  - Sound is produced by a vibrating body.
- **Vibration :** The to and fro (or) back and forth motion of an object is called vibration.
- In human body sound is produced by the voice box or the larynx.
- When the vocal cords are tight and thin the type or quality of voice is different from that when they are loose and thick.
  - The vocal cards in men are about 20 mm long.
  - The vocal cards in women are about 15 mm long.
  - The vocal cards in children are very very small.
- Sound needs a medium to travel.
- Sound cannot travel through a vacuum.
- Sounds can travel through wood or metal (solid).
- The shape of the outer part of the ear is like a funnel.
- The eardrum is like a stretched rubber sheet.
- **Oscillatory motion :** The vibratory motion is also called oscillatory motion.
- **Frequency :** The no.of oscillations per second is called the frequency of oscillations.
  - Frequency is expressed in hertz (Hz).
  - 1 Hz = one oscillation per second.
- Amplitude and frequency are two important properties of sound.
  - The loudness of sound depends on its amplitude.
  - The frequency determines the shrillness or pitch of a sound.
  - A body vibrates with low frequency produces a low pitched sound.
- The frequency less than 20 Hz can't be detected by the human ear.
- Frequency higher than 20,000 Hz are also not audible to human ear.
- Human audible range is 20 Hz to 20,000 Hz.
- **Noise :** Unpleasant sounds are called Noise.
- **Music :** Pleasant sounds are called musical sounds.
- The noise pollution cause, lack of sleep, hypertension, anxiety and more health problems.
- Noise pollution can be redused by :
  - By using proper silencing devices for auto mobiles.
  - Uses of horns of automobiles is minimized.
  - Trees must be planted along the roads.
- The presence of excessive or unwanted sounds in the environment is called noise pollution.
- Sounds of vehicles, loud speakers, crackers are source of noise pollution.

NCERT TEXTUAL QUESTIONS

1 How does the 'Sound' produced by a vibrating object in a medium reach your ear ? **(Understanding)**

A. The vibrating object produces compression and rarefraction pulses, one after the other in the medium. These pulses travel one behind the other as the sound wave. When this sound wave reaches our ear, it forces the tympanic membrane to vibrate and thus causing the sensation of hearing



2. Explain how sound is produced by your school bell. **(Understanding)**

A. When the school bell is hit by a hammer, it begins to vibrate and start to and fro motion as a result, sound produced.

3. Why are sound waves called mechanical waves ? **(Understanding)**

A. Sound waves require a medium, and cannot propagate without a medium. Hence sound waves are called mechanical waves.

4. Suppose you and your friends are on the moon can you be able to hear any sound produced by your friend. **(Analyzing and Evaluating)**

A. No, we are not able to hear any sound produced by our friend because there is no atmosphere on the moon. without air medium sound wave cannot reach from our friend's mouth to our ear.

5. Which wave property determines a) loudness , b) pitch ? **(Understanding)**

A. a) Loudness is determined by the amplitude of the wave.

b) Pitch is determined by the frequency of the wave.

6. Guess which sound has a higher pitch: guitar or car horn? **(Creating)**

A. The frequency of the vibration of a sound produced by a guitar is greater than that produced by a car horn. Since the pitch of sound is proportional to its frequency, the guitar has a higher pitch than a car horn.

7. What are wavelength, frequency, time period and amplitude of a sound wave? **(Understanding)**

A. **Wavelength :** The linear distance between two consecutive compression or two consecutive rarefractions is known as wavelength.

Frequency : The number of compressions and rarefractions (taken together) passing through a point in unit time is known as frequency.

Time period : The time taken by two consecutive compressions or rarefractions to pass through a point is known as time period.

Amplitude : The extent to which a medium is compressed,when a sound wave passes through it is called amplitude.

8. How are the wavelength and frequency of a sound wave is related to is speed? (Understanding)

A. Speed of sound = Frequency × Wavelength

$\Rightarrow v = \vartheta\lambda$

9. Calculate the wavelength of a sound wave whose frequency is 220 Hz and speed is 440 ms^{-1} in a given medium. (Applying)

A. Frequency = 220 Hz; speed of sound = 440 ms^{-1}

Speed of sound = Frequency × Wavelength

440 = 220 × Wavelength

$\therefore$ Wavelength $= \frac{440}{220} = 2$ m

10. A person is listening to a tone of 500 Hz sitting at a distance of 450 m from the source of sound. What is the time interval between successive compressions from the source? (Applying)

A. Time interval $= \frac{1}{\text{Frequency}}$

$= \frac{1}{500} = 0.002\,s.$

11. Distinguish between loudness and intensity of sound. (Understanding)

A. Intensity depends on the energy per unit area of the wave and it is independent of the response of the ear, but the loudness depends on energy as well as on the response of the ear.

12. In which of the three media, air, water and iron, does sound travel the fastest at a particular temperature ? (Analyzing and Evaluating)

A. Sound travels the fastest in iron.

13. An echo returned in 3 s. What is the distance of the reflecting surface from the soruce, given the speed of sound is 342 ms^{-1}? (Applying)

A. Here time of echo t = 3 s, speed of sound

$v = 342\ ms^{-1}$

$\therefore$ Distance of the reflecting surface from the source

$d = \frac{vt}{2} = \frac{342 \times 3}{2} = 513\,m$

14. Why are the ceilings of concert halls curved? (Creating)

A. Ceiling of concert halls, conference halls, cinema halls etc., are curved so that sound after reflection reaches all corners hall.

15. What is the audible range of the average human ear? (Creating)

A. For an average human ear the audible range extends from 20 Hz to 20000 Hz (or 20 kHz).

16. What is the range of frequencies associated with (Creating)

a) Infrasound

b) Ultrasound

A. a) Sound of frequencies below 20 Hz are called infrasound.

b) Ultrasounds have a frequency greater than 20 kHz.

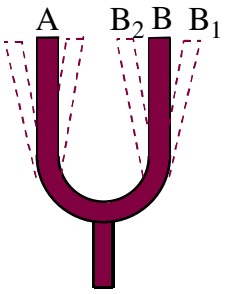
NCERT TEXTUAL EXERCISES QUESTIONS

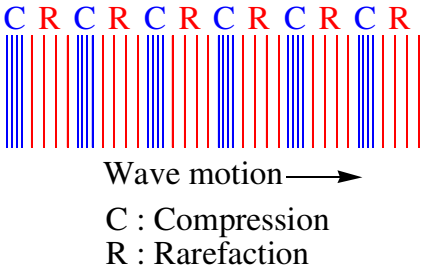
1. What is sound ? How it is produced? (Understanding)

A. Sound is a form of energy which causes sensation of hearing in our ears. Sound is produced due to vibrations (oscillations) of different objects.

2. Describe with the help of a diagram, how compressions and rarefractions are produced in an air near a source of sound. (Understanding)

A. **Propagation of sound through air :** Sound travels through air in the form of longitudinal waves. Consider a vibrating tuning fork producing sound waves as shown in the figure. Its both prongs first move inward and then outwards and so on. We focus our attention to prong B only. As this prong moves from B to B_1, it compresses the layer of air in front of it As this compressed layer moves forwards, it compresses the next layer and so on. So a wave of compression moves forward. When the prong moves backward from B_1 to B_2 , the pressure of air in the adjoining layer decreases. The next layer, being at higher pressure tends to move it towards right and so on. So a wave of rarefractions moves forward. The vibrating tuning fork continues to send a series of compression and rarefactions. These waves finally reach the ear and force the tympanic membrane to vibrate with their frequency and thus cause the sensation of hearing.





Compression is the region of high pressure and rarefraction is the region of low pressure. Higher the pressure in a region, higher is the number of particles per unit volume and hence higher is the density of the medium. So a sound wave propagates through a medium as the variation in its pressure or density.

3. Why is sound wave called a longitudinal wave ? (Analyzing and Evaluating)

A. It is called longitudinal wave because the particles of the medium vibrate in the direction of the propagation of wave.

4. Which characteristic of sound helps you to identify your friend by his voice while sitting with others in a dark room ? (Analyzing and Evaluating)

A. The characteristic of sound is quality or timber.

5. Flash and thunder are produced simultaneously. But thunder is heard a few second after the flash is seen. Why ? (Creating)

A. The speed of light is 3×10^8 ms^{-1}, whereas that of sound is 344 ms^{-1} in air. Thus, flash of lightning is seen at once, but sound takes few seconds to reach the ears.

6. A person has a hearing range from 20 Hz to 20 kHz. What are the typical wave lengths of sound waves in air corresponding to these two frequencies ? Take the speed of sound in air as 344 ms^{-1} (Applying)

A. Wavelength of sound of frequency 20 Hz $= \frac{\text{Speed of sound}}{\text{frequency}} = \frac{344 \text{ ms}^{-1}}{20 \text{ s}^{-1}} = 17.2 \text{ m}$

Wavelength of sound of frequency 20,000 Hz $= \frac{\text{Speed of sound}}{\text{Frequency}} = \frac{344 \text{ms}^{-1}}{20{,}000 \text{s}^{-1}} = 0.0172 \text{m}$

7. Two children are at opposite ends of an aluminium rod. One strikes the end of the rod with a stone. Find the ratio of time taken by the sound wave in air and in aluminium to reach the child. (Speed of sound in aluminium and in air are 6420 ms^{-1} and 346 ms^{-1} respectively). (Applying)

A. $$\frac{\text{Time to travel in aluminium}}{\text{Time taken by sound in air}} = \frac{\text{Speed of sound in air}}{\text{Speed of sound in aluminium}}$$

or $$\frac{T_{Al}}{T_{air}} = \frac{346 ms^{-1}}{6420 ms^{-1}}$$

or $T_{Al} : T_{air} = 346 : 6420$

$= 1 : 18.55.$

8. The frequency of sound source is 100 Hz. How many vibrations can it make in one minute. (Applying)

A. The frequency of sound is $\vartheta = 100$ Hz

Time t = 1minute = 60 s

$\therefore$ Total number of vibrations made $n = \vartheta \times t$

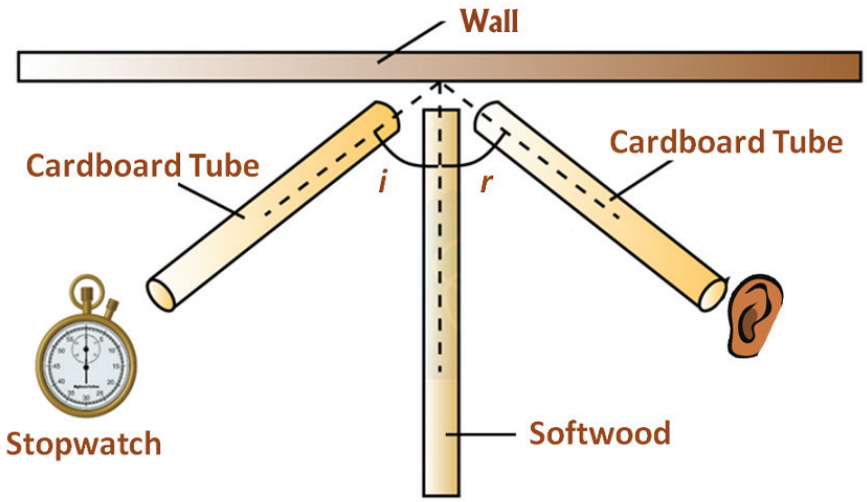
$= 100 \times 60 = 6000.$

9. Does sound follow the same laws of reflection as light does ? Explain. (Creating)

A. Yes, sound follow the same laws of reflection as light does.

To explain it and to demonstrate it experimentally, we take two identical pipes and arrange them on a table near a wall. Keep a clock near the open end of one pipe. Try to hear the sound of clock by putting our ear near the open end second pipe. Adjust the orientations of the pipes so that sound of clock is clearly heard at the open end of second pipe. Now measure the angle of incidence 'i' and the angle of reflection 'r'. We find that angle of incidence is equal to angle of reflection i.e., $\angle i = \angle r$.

If we lift the 2nd pipe to a small height, then we are unable to listen the sound of clock. It shown that incident wave and reflected wave lie in same plane.



10. When a sound is reflected from a distant object, an echo is produced. Let the distance between the reflecting surface and the source of sound production remains the same. Do you hear echo sound on a hotter day ? (Understanding)

A. When a sound is reflected from a distant object situated at a distance d, the echo is produced due to reflected sound. The time of echo is given by $t = \frac{2d}{v}$, where u is speed of sound. On a hotter day, the speed of sound will be comparatively more. As a result, the echo sound will be heard after a lesser time. It means that echo sound is heard sooner on a hotter day than on a colder day for a given distance between the sound source and reflecting surface.

11. Give two practical applications of reflection of sound waves. (Understanding)

A. Two practical applications of reflection of sound waves are given below :

i) Megaphones, horns, trumphets etc., are designed to send sound in a particular direction without spreading it in all directions. In these devices, a tube following by a conical opening reflects sound successively to guide the sound waves from the source in the forward direction towards the audience.

ii) In stethoscope, the sound of the patient's heartbeat reaches the doctor's ears by multiple reflection of sound inside the tube of stethoscope.

12. A stone dropped from the top of a tower 500 m height into a pond of water at the base of the tower. When is the splash heard at the top ? (Given g = 10 ms^{-2} and speed of sound = 340 ms^{-1}). (Applying)

A. Time, after which splash is heard = time taken by the stone to reach the surface of water in a pond + time taken by the sound of splash to reach the top of water.

i) Here, $u = 0$, $s = 500m$, $g = 10\ ms^{-2}$

using, $s = ut + \frac{1}{2} gt^2$, $\Rightarrow 500 = 0 + \frac{1}{2} gt^2$,

or $t^2 = 100$ or $t = 10$ s

Thus, time taken by the stone to reach the surface of water = 10s

ii) Here, s = 500 m,v = 340 ms^{-1}
using s = ut, we get

$$t = \frac{s}{u} = \frac{500}{340} = 1.47s$$

Thus, time taken by the sound to reach by the top of water = 1.47s

$\therefore$ Time, after which splash is heard = 10s + 1.47s = 11.47s

13. A sound wave travels at a speed of 339 ms^{-1}. If its wavelength is 1.5 cm, what is the frequency of the wave ? Will it be audible ? (Applying)

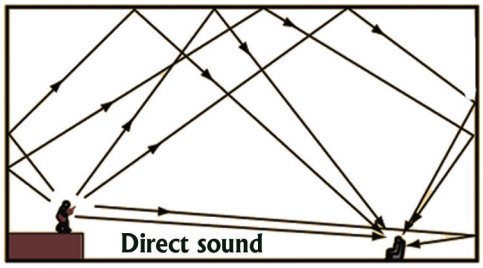
A. Wavelength of sound wave = 1.5 cm = 0.015 m.
Speed of sound wave = 339 ms^{-1}

$\therefore$ Frequency of sound wave = $\frac{\text{Speed of sound}}{\text{Wavelength}} = \frac{339ms^{-1}}{0.015m} = 22600$ Hz

The sound will not be audible, because humans can hear only upto 20,000 Hz.

14. What is reverberation ? how can it be reduced ? (Understanding)

A. The repeated multiple reflections of sound in any big enclosed space is known as reverberation. The reverberation can be reduced by covering the ceiling and walls of the enclosed space with saved aborbing materials, such as fibre board, loose woolen, etc.



15. What is a loudness of sound ? What factors does it depens upon ? (Understanding)

A. The effect produced in the brain by the sound of different frequencies is called loudness of sound. The loudness of sound increases with the increase in amplitude and the area of the vibrating body. It also depends on the distance of the observer from the source of sound, i.e., less the distance loud is the sound.

16. How is ultrasound used for cleaning ? (Creating)

A. The object to be cleaned is placed in a tank fitted with ultrasonic vibrator. The tank is filled with water containing detergent. When the ultrasonic vibrator is switched on the detergent particles rub against the object at a very high speed and hence clean it.

17. Explain how defects in a metal block can be detected using ultrasound ? (Creating)

A. The ultrasound waves are allowed to pass through metal block to which are fitted detectors to detect the waves. If the metal block has a very small defect, such as an air bubble or a crack, then the ultrasound waves are reflected from such spots. The reflected ultrasonic waves indicated that metal block is defective.

TEXT BOOK SOLVED PROBLEMS

1. A sound wave has a frequency of 2 kHz and wave length 35 cm. How long will it take to travel 1.5 km? (Applying)

A. Given,

Frequency, ϑ = 2 kHz = 2000 Hz

Wavelength, λ = 35 cm = 0.35 m

We know that speed, v of the wave = wavelength × frequency

$$v = \vartheta\lambda$$

$$= 0.35 \text{ m} \times 2000 \text{ Hz} = 700 \text{ m/s}$$

The time taken by the wave to travel a distance, d of 1.5 km is

$$t = \frac{d}{v} = \frac{1.5 \times 1000m}{700ms^{-1}} = \frac{15}{7}s = 2.1s$$

Thus sound will take 2.1 s to travel a distance of 1.5 km.

2. A person clapped his hands near a cliff and heard the echo after 2 s. What is the distance of the cliff from the person if the speed of the sound, v is taken as 346 m s^{-1}? (Applying)

A. Given,

Speed of sound, v = 346 m s^{-1}

Time taken for hearing the echo, t = 2 s

Distance travelled by the sound = $v \times t$ = 346 m s^{-1} × 2 s = 692 m

In 2 s sound has to travel twice the distance between the cliff and the person.

Hence, the distance between the cliff and the person = 692 m/2 = 346 m.

ADDITIONAL QUESTIONS

I. COMPETENCY - DEMONSTRATE KNOWLEDGE AND UNDERSTANDING

1. What is the nature of sound waves ?

A. The nature of sound waves is longitudinal.

2. Give one example of transverse and longitudinal waves ?

A. Light waves are transverse where as sound waves are longitudinal.

3. Name the factor on which loudness of a sound depend ?

A. Loudness of a sound depends on amplitude of the wave.

4. On what factor does the quantity of the sound depend ?

A. The quantity of sound depends on the change in wave form.

5. What is velocity of sound on moon ?

A. It is zero.

6. Mention three characteristics of sound waves. State the factors on which they depend ?

A. Characteristics of a sound wave :

i) **Pitch :** The pitch of the sound is determined by the frequency of sound.

ii) **Loudness :** The loudness of sound is determined by the amplitude of its wave.

iii) **Quality :** Quality is determined by wave forms of different sound waves of same frequency and same loudness.

7. State the term used for repeated reflection, that results in the persistence of sound. How can this sound be reduced in an auditorium?

A. Reverberation is used for repeated reflection, that results in the persistence of sound. This sound can be reduced when the walls and the ceiling of the hall are covered with sound absorbing materials, such as loose woollen, cotton clothes, fiber board etc.

8. What are wavelength, frequency, time period and amplitude of a sound wave ?

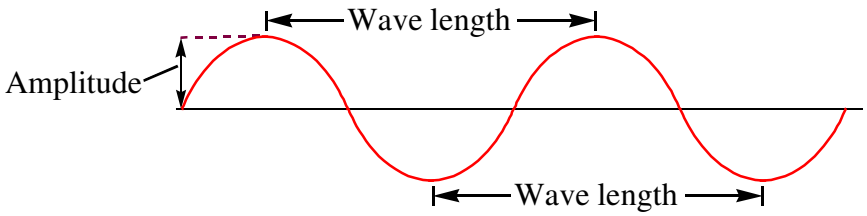
A. **Wavelength :** It is the distance between two consecutive compressions or two consecutive rarefactions. It is usually represented by λ and its SI unit is metre.

Frequency : It is the number of oscillations completed in a unit time. It is represented by υ and its SI unit is s^{-1} (or) hertz (Hz).

Time period: It is the time taken to complete one vibration. It is represented by T and its SI unit is second.

$$T = \frac{1}{\vartheta} \text{ or } \vartheta = \frac{1}{T}$$

Amplitude : It is the maximum displacement in the medium on either side of the mean position. It is usually represented by A and its SI unit is metre.



9. What are applications of ultrasound ?

A. **Applications of ultrasound :**

i) Glaton whistle : It is used by hunters. When hunter and sound get separated and hunter wants to call back dog to help him catch the prey, he blow the Glaton whistle which produces only ultrasonic waves and can be heard by dog but not by other animals and birds of the forest.

ii) Bats judge the distance of prey or the coming obstacle by sending these waves. By observing the time taken by waves to travel back, they can find the distance of the obstacle / prey.

iii) Ultrasound waves are used to find the depth of the sea(for details echo sounding ahead).

iv) Ultrasonic waves are used by doctors for scanning different parts of the body.

v) These are used by dentists to compress the silver filled in the cavity of teeth.

vi) These are used to clean parts located in hard to reach places. Objects are cleaned in cleaning solution and ultrasonics are passed in the solution. Particles of dust, grease get detached due to high frequency vibrations and get into cleaning solution.

vii) In echocardiography, we can form image of different parts of heart by reflecting and observing the reflected ultrasonic waves.

viii) Ultrasound can be used to detect and locate cracks in the metal blocks.

ix) Doctors can produce images of internal organs such as kidney, uterus, liver and gall bladder.

x) These are used to crush stones in kidney to fine grains. These can be flushed out from the body with urine.

10. What happens to speed of sound when it goes from solid to gaseous state ?

A. Speed of sound is decreased when goes from solid to gaseous state.

11. Which wave property determines loudness ?

A. Amplitude determines loudness. Loudness depends upon intensity of sound. Intensity of sound is proportional to square of the amplitude of wave. Hence loudness also depends upon sqaure of the amplitude of wave. Loudness depends upon intensity of sound as well as sensitiveness of ear.

12. Explain which property determines pitch ?

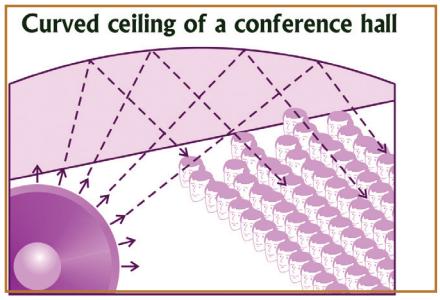
A. Pitch depends upon frequency of sound. More the frequency, higher the pitch of sound. Shrillness of sound depends upon its pitch. More the pitch, shriller the sound.

13. Why are sound waves are called mechanical waves ?

A. These are called mechanical waves because these are produced due to forward and backward motion of the material particles. Sound cannot travel in vacuum. Material medium is essential for the production of sound waves.

14. Why are the ceilings of concert halls curved ?

A. Ceiling of concert halls, conference halls etc., are curved so that sound after reflection reaches all corners of hall. Sometimes curved sound board is placed behind the stage so that after reflection sound from the sound board spreads evenly across the width of the hall.

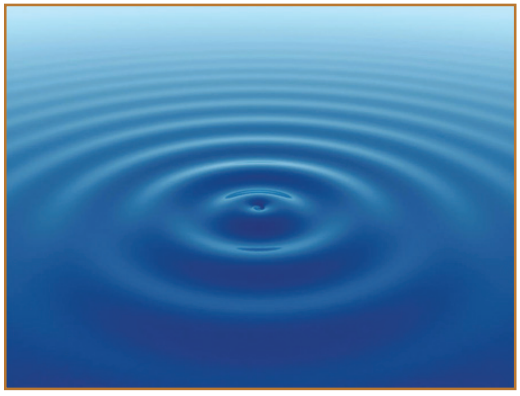


15. What is a wave motion ? Discuss an example of wave formed on the surface of a pond. Name the wave produced.

A. **Wave motion :** It is the disturbance created in the medium through which energy can transfer from one place to another place. There are two types of wave motions.

i) Transverse wave motion,
ii) Longitudinal wave motion.

When a stone is dropped in a pool of still water, waves start from the point where the water is disturbed and widen out in concentric circles. It is an optical illusion because there is no actual displacement of water as the waves sweep over its surface, Actually every drop rises and falls without moving forward and backward. This can be verified by placing a cork on the surface of water. The cork merely tosses up and down without any bodily displacement.



16. Expalin how sound is produced by your school bell ?

A. When the school bell is struck by a hammer, it starts moving forward and backward due to elasticity and inertia. During forward motion of the bell, a wave of increased pressure i.e., compression is produced. When the bell moves backward, a wave of rare refraction i.e., a wave of decreased pressure is produced. When series of compressions and rare fractions reach our ear, it results in the production of sound in our ear.

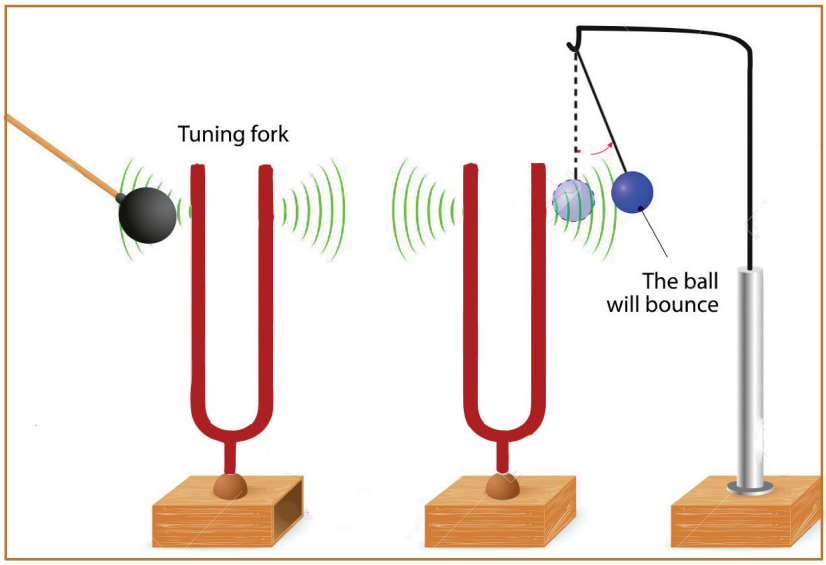
17. Explain with an activity that shows a vibrating body produces sound ?

A. Take a tuning fork and set it vibrating by striking its prong on a rubber pad. If you bring it near your ear, you can hear sound.

Now verify the tuning fork is vibrates or not with the following activity.

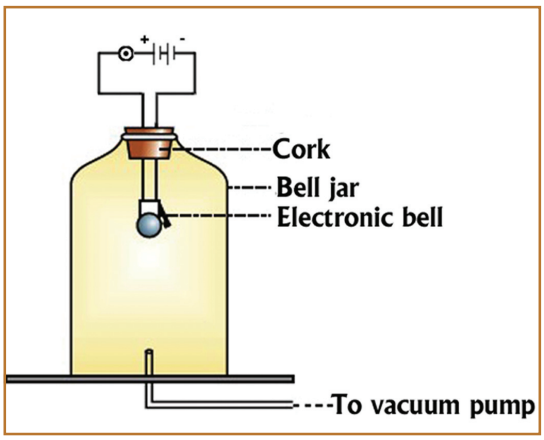
Activity : Suspend a table tennis ball or a small plastic ball by a thread from a support as shown in figure. Touch the ball gently with the prong of a vibrating tuning fork. We will obsesrve that when the vibrating tuning fork touches the ball, the ball fly off from it's original position.

The above activity shows that vibrating bodies produces sound.



18. Write an experiment to show that sound needs a material medium for its propagation.
(Understanding)

A. Take an electric circuit consisting of a cell and an electric bell is arranged inside a bell jar which stands on the platform of an evacuating pump. The switch of the bell is pressed to close the electric circuit. Sound is heard when there is air within the bell jar. Air is now gradually pumped out of the bell jar. The intensity of sound goes on decreasing, and no sound is heard when the air is completely removed from the bell jar as shown in Figure. It is because, the medium of air, which has to carry energy from the bell to the bell jar, is removed. This clearly shows that sound needs material medium for its propagation.



19. Explain transvers wave motion with one exmaple.

A. Transverse Wave Motion. A wave motion in which an individual particle of the medium vibrate in a direction at right angles to the direction of propagation of wave is called transverse wave motion.

For transverse wave motion to be set up, a medium must possess

i) Elasticity i.e., a tendency to gain back their normal position when disturbed,

ii) Inertia, so that the particle overshoots the mean position,

iii) Force of cohesion so that the motion is gradually handed over from one particle to the next.

In the case of waves formed over the surface of water, the individual particles of wave oscillate in a direction at right angles to the direction of propagation of wave. Such a wave motion in which the individual particles of the medium vibrate in direction at right angles to the direction of propagation of the wave is called transverse wave.

Examples of Transverse Waves

i) Water ripples on the surface of water.

ii) Vibration of stretched strings e.g., when a stretched string of a sitar, tanpura or violin is plucked, transverse waves are set up in the wire.

iii) Wave produced by up and down motion of rope with one end tied to a fixed support.

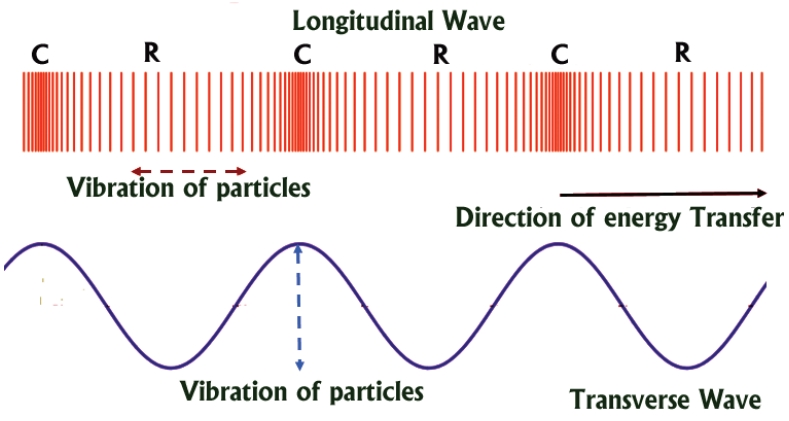
iv) Light and radio waves are also transverse in nature.

20. Explain longitudianal wave motion with one example.

A. **Longitudinal wave motion :** A wave motion in which the individual particles of the medium vibrate back and forth along the direction of propagation of the wave is called the longitudinal wave motion. Sound in air gets propagated in the form of longitudinal wave motion consisting of regions of compressions and rarefactions.

Consider, for example, a tuning fork in a state of vibration . As air has elasticity, the compressed air tends to relieve itself its strain and move forward to right to compress the next layer and so on. Thus, a wave of compression moves towards the right. In wave form it has been shown in Figure. At the point of compression, there is an increase of pressure and is shown in form of crest C.At the point of rarefaction of concentration of particles is least and has been shown as through R.

When the prong moves to ards left, a region of reduced pressure or rarefaction is produced towards right .The air in the next layer, being at a higher pressure, moves towards the left to equalize the reduced pressure producing another rare fraction region to its right and so on. Thus, a wave of rarefaction starts moving in forward direction. These compressions and rarefactions finally reach the ear - drum of the observer and force it into corresponding vibrations and we hear sound.



21. What are travelling or progressive waves ? Can there be a combination of longitudinal and transverse waves ?

A. Transverse as well as longitudinal waves are both mechanical waves and are called travelling or progressive waves. The transverse waves travel from one end of stretched slinkey to the other end whereas longitudinal waves travels from one end to the other. In both the cases, the disturbance travels between two points from one end to the move from one point to another.

We know the waves travelling a long slinky are transverse in nature where as sound waves propagated in air are longitudinal. There is present also another type of wave which is neither purely transverse nor longitudinal but is a combination of the two.

A point in a medium travels in either a circle or an ellipse as wave passes. Ocean waves in deep water are combination of two types of waves. Seismic wave which causes earthquake is also combination of two types of waves.

22. Why the speed of sound is different in different media ?

A. Speed of sound is different in different media. The speed of sound depends upon the properties of the medium through which it travels and also upon the temperature. Speed of sound increases with the increase of temperature.However, it does not depend upon the pressure of the gas through which it travels.Speed of sound is maximum in solids, lesser in liquids and least in gases. Speed of sound in lighter gases is more than heavier gases.Speed of sound in hydrogen is nearly four times then its speed in oxygen at the same temperature.

23. Ear is placed at one end of a long tube of iron and a person strikes at the other end. The sound of striking is heard two times, Why ? Which sound is heard first and why ?

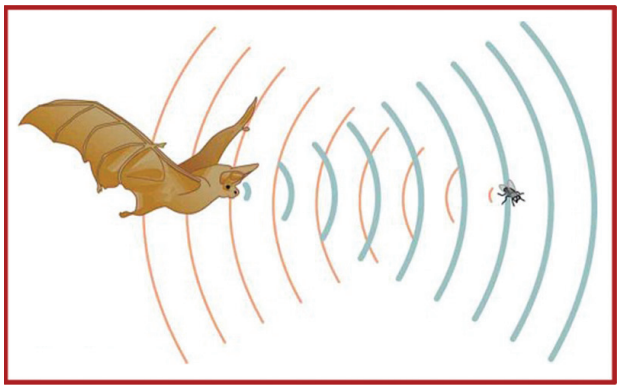
A. Sound of striking is heard two times because the speed of sound in iron is different from that in air. Hence two sound waves are travelling through iron and other air, reach the other end at different times. Sound through steel is heard first because speed of sound in steel is greater than that in air.

24. Sound of explosion taking place on other planets are not heard by a person on the earth. Explain why?

A. Sound needs material medium for its propagation from one place to another place. In other words, sound cannot travel through vacuum. Since there is a region in between the planets and the earth, there is a vacuum , so the sound of explosions taking place on other planets cannot pass through this vacuum. Hence cannot reach the earth.

25. Explain how the bats can know distances, direction, nature and size of the obtstcles without any eyes?

A. The bats can emit ultrasonic waves (sound waves of frequency above 20 kHz). The waves emitted by the bats are reflected by the obstacles and is received back by it. Bats can also detect ultrasonic waves. The time interval between the emission of ultrasonic wave and its reception back after reflection gives the information of the distance, nature of obstacles, direction, nature and size of the object inspite of their poor eyesight.



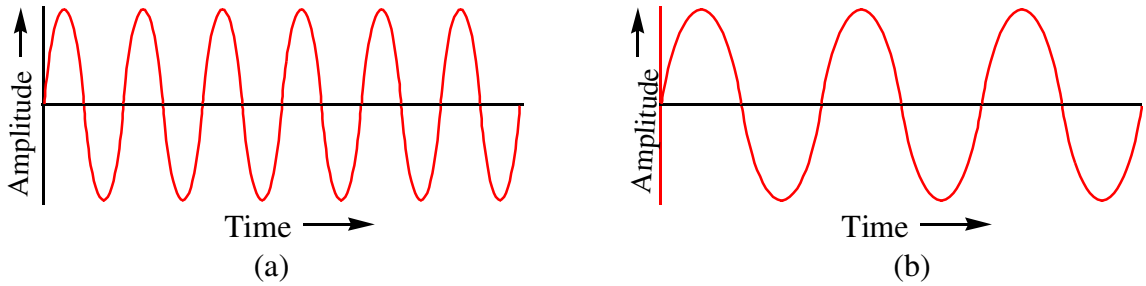
26. Represent graphically two separate diagrams in each case.

i) Two sound waves having the same amplitude but different frequencies.

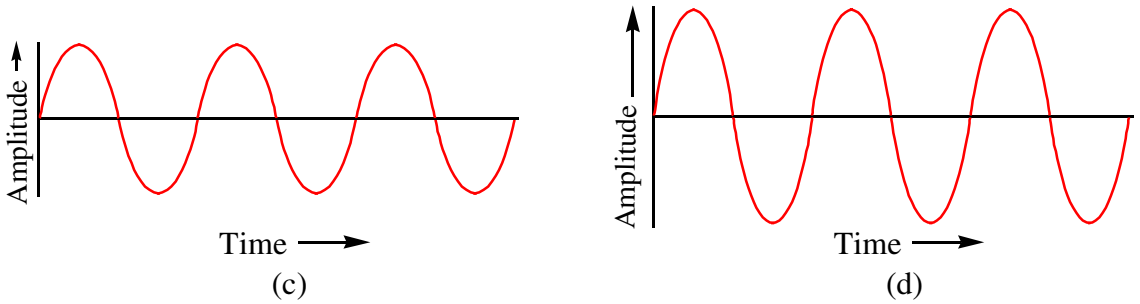
ii) Two sound waves having the same frequency but different amplitudes

iii) Two sound waves having different amplitudes and also different frequencies.

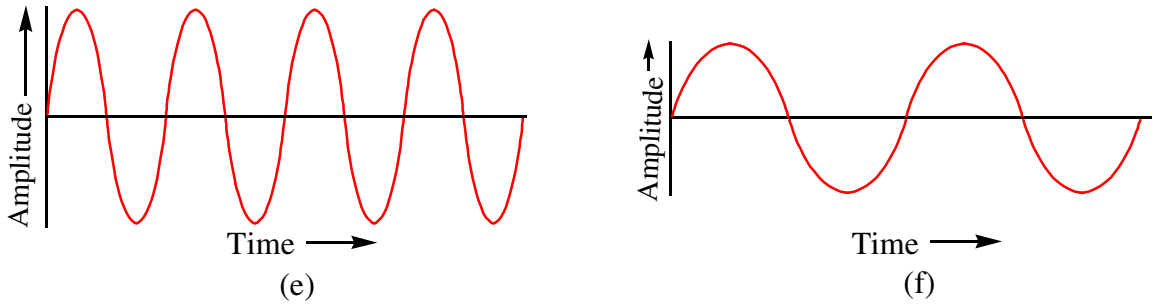
A. i) Graphs (a) and (b) represents similar amplitude but different frequencies.



ii) Graphs (c) and (d) represents same frequency and different amplitudes.

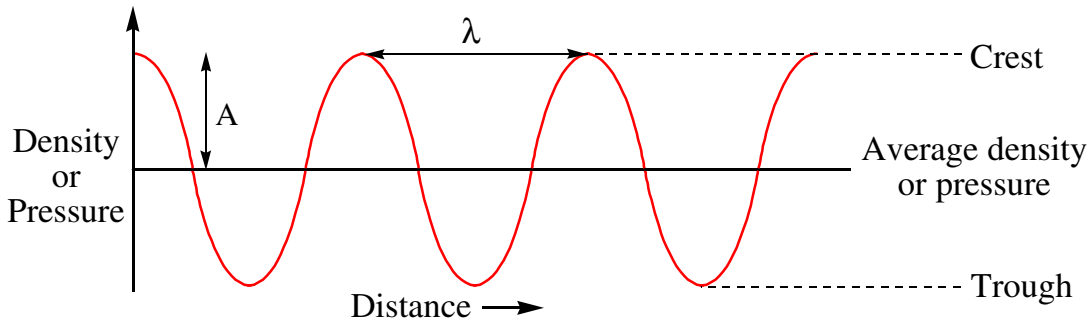


iii) Graphs (e) and (f) represents different amplitudes and also different frequencies.



27. Draw a curve showing density or pressure variations with respect to distance for a disturbance produced by sound. Mark the position of compression and rarefraction on this curve. Also define wavelength and time period using this curve.

A. Required graph is as shown in fig. Wavelength is the distance between two consecutive compressions (crests) or between two consecutive rarefractions (troughs) shown by λ in figure. Time period is the time taken to travel the distance between any two consecutive compressions or consecutive rarefractions from a fixed point.



II. COMPETENCY - APPLICATION OF KNOWLEDGE/CONCEPTS

1. Determine the wavelength of an ultrasonic wave of frequency 4.2 MHz. The speed of ultrasonic wave is 1.7 km/s

A. Hence frequency,

ϑ = 4.2 MHz = 4.2×10^6 Hz , v= 1.7 km/s = 1.7×10^3 m/s

Wavelength, $\lambda = \frac{v}{\vartheta} = \frac{1.7\times10^3}{4.2\times10^6} = \frac{17}{42}\times10^{-3}$ m

$= 0.405 \times 10^{-3}$m = 0.405 mm

Thus, wavelengh of ultrasonic wave = 0.405 mm

2. A sound wave travels at a speed of 330 m/s If its wavelength is 1.5 cm, calculate the frequency of the sound wave.

A. Given v = 330 m/s , λ = 1.5 cm = 1.5×10^{-2} m

f = ?

Frequency, $f = \frac{v}{\lambda} = \frac{330}{1.5\times10^{-2}}$ = 22×10^3Hz = 22 kHz

3. If 25 sound waves are produced per second, what is the frequency in hertz ?

A. The frequency in hertz is equal to the number of waves produced per second. In this case, since 25 waves are being produced per second, so the frequency of the sound waves is 25 hertz (which is also written as 25 Hz).

4. What is the frequency of a sound wave whose time-period is 0.05 s ?

A. The relationship between the frequency and time-period of a wave is : $f = \frac{1}{T}$

here, frequency, f = ? (To be calculated)

Time-period, T = 0.05 s

Putting this value in the above relation, we get : $f = \frac{1}{0.05} = \frac{100}{5}$

f = 20 Hz

Thus, the frequency of the sound wave is 20 hertz.

5. Sound waves travel with a speed of about 330 m/s. What is the wavelength of sound whose frequency is 550 hertz ?

A. Here, Speed of waves, v = 330 m/s , Frequency of waves, f = 550 Hz

and, Wavelength, λ = ?

Now, $v = f \times \lambda$

So, $330 = 550 \times \lambda$

$$\lambda = \frac{330}{550} \Rightarrow \lambda = 0.6 \text{ m}$$

Thus, the wavelength of sound waves is 0.6 metre.

6. Sound produced by a thunderstorm is heard 10s after the lightning is seen. Calculate the approximate distance of the thunder cloud. Given speed of sound = 340 ms^{-1}.

A. Given time (t) = 10 s , Speed (v) = 340 m/s

$\therefore$ Distance, s = vt = 340 × 10

= 3400 m

= 3.4 km.

7. Derive a relation between Wave velocity, Wavelength and Frequency.

A. The distance travelled by a wave in 1 s is called wave velocity. Wavelength is the distace travelled by the wave during one complete vibration of the vibrating particle. Thus if λ in time T. The distance travelled by the wave in one second or the velocity v is given by

$$v = \frac{\lambda}{T} = \lambda \times \frac{1}{T}$$

But frequency $n = \frac{1}{T}$

$\therefore$ $v = \lambda n = n\lambda$

8. If velocity of sound in air is 340 ms^{-1}, calculate :

i) Wavelength when frequency is 256 Hz.

ii) Frequency when wavelength is 0.85 m.

A. i) Here v = 340 m s^{-1}; λ = ?, ϑ = 256 Hz

$$v = \vartheta\lambda \text{ or } \lambda = \frac{v}{\vartheta}$$

$$\lambda = \frac{340}{256} = 1.33\text{m}$$

ii) Here v = 340 m s^{-1} ; ϑ = ? λ = 0.85 m

$$\vartheta = \frac{v}{\lambda} = \frac{340}{0.85}$$

ϑ = 400 Hz.

9. A man claps his hands near a mountain and hears the echo after 4 second. If the speed of sound under these conditions be 330 m/s, calculate the distance of the mountain from the man.

A. Here the time taken by the sound (of clap) to go from the man to the mountain, and return to the man (as echo) is 4 seconds. So, the time taken by the sound to go from the man to the mountain only will be half of this time, which is $\frac{4}{2} = 2$ second. Now knowing the speed of sound in air, we can calculate the distance travelled by sound in 2 second. This will give us the distance of the mountain from the man.

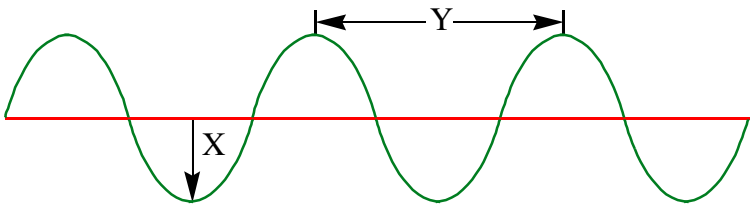
We know that, $\text{Speed} = \frac{\text{Distance travelled}}{\text{Time taken}}$

So, $330 = \frac{\text{Distance travelled}}{2}$

And, Distance travelled = 330×2 metre = 660 metre

Since sound travels a distance of 660 metre in going from the man to the mountain, therefore, the distance of mountain from the man is 660 metre.

10. A sound wave travelling in a medium is represented as shown in figure.



i) Which letter represents the amplitude of the sound wave ?

ii) Which letter represents the wavelength of the wave ?

iii) What is the frequency of the source of sound if the vibrating source of sound makes 360 oscillations in 2 minutes.

A. i) Letter X represents the amplitude of the sound wave.

ii) Leter Y represent the wavelength of the sound wave.

iii) Number of oscillations made in 2 minutes (120 s) = 360

Number of oscillations make in 1 second $= \frac{360}{120s} = 3s^{-1}$ or Hz

11. An echo is heard on a day when temperature is about 22°C. Will the echo be heard sooner or later if the temperature falls to 4°C ?

A. Time after which an echo is heard is given by $\frac{\text{Distance}}{\text{Speed of sound in air}}$

Since speed of sound in air decreases with the decreases in temperature, so the time after which the echo will be heard later than the echo heard when the temperature was 22°C.

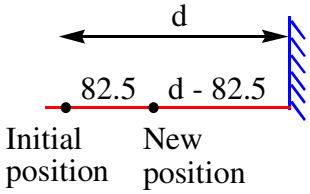
12. A man standing infront of a vertical cliff fires a gun. He hears the echo after 3 s. On moving closer to the cliff by 82.5 m, he fires again and hears the echo after 2.5 s. Find :

i) The distance of cliff from the initial position of man,

A. Figure shows the two positions of the man infront of a cliff.

Let distance of cliff from the initial position of man be d m and speed of sound be V ms^{-1}.

For the first echo, $t = \frac{2d}{V} = 3s$ (given) ..... (i)



On moving closer to the cliff by 82.5 m, the distance of cliff from the new position becomes

(d - 82.5) m, then for second echo

$$t = \frac{2(d-82.5)}{V} = 2.5s \text{ (given)} \quad \text{..... (ii)}$$

Dividing eqn. (i) by eqn. (ii), we get

$$\frac{d}{d-82.5} = \frac{3}{2.5} = \frac{6}{5} \text{ (or) } 6d - 495 = 5d \text{ (or) } d = 495 \text{ m}$$

ii) The speed of sound.

A. From eqn. (i), $V = \frac{2d}{t}$

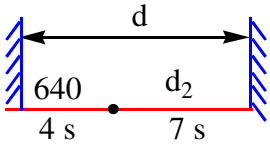
Substituting the value of d = 495 m, and t = 3 s

$$V = \frac{2 \times 495}{3} = 330\, ms^{-1}$$

13. A person standing between the two vertical cliffs and 640 m away from the nearest cliff, produces sound, He hears the first echo after 4 s and the second echo 3 s later. Calculate :

i) the speed of sound in air

A. Figure shows the two cliffs and the position of the person.



First echo is heard from the nearest cliff.

Let d_1 be the distance of the nearest cliff 1 from the person.

Total distance travelled by the sound in going and then coming back = $2d_1$

= 2 × 640 m = 1280 m

Time taken t = 4 s

$$\therefore \quad \text{Speed of sound} = \frac{\text{total distance travelled}}{\text{time taken t}} = \frac{1280\, m}{4s} = 320\, ms^{-1}$$

ii) The distance between the cliffs.

A. The second echo is heard from the farther cliff 2. If d_2 is the distance of the farther cliff 2 from the person, then total distance travelled by the sound in going and then coming back = $2d_2$

Time taken t = 4 + 3 = 7 s

Now $V = \frac{2d_2}{t}$

$$\therefore \quad d_2 = \frac{Vt}{2} = \frac{320 \times 7}{2} = 1120m$$

Hence distance between the two cliffs 1 and 2 = $d_1 + d_2$ = 640 m + 1120 m = 1760 m

14. A device called oscillator is used to send waves along a stretched string. The string is 20cm long, and four complete waves fit along its length when the oscillate vibrates 30 times per second. For the waves on the string ?

a) What is their wavelength ?

b) What is their frequency ?

c) What is their speed ?

A. a) 5 cm or 0.05 m

b) 120 Hz

c) 6 m/s

15. The longitudinal waves are travelling in a coiled spring of a rate of 4 m/s. The distance between two consecutive compressions is 20cm. Find:

i) Wavelength of the wave **ii) Frequency of the wave**

A. i) 20cm ii) 20 Hz

III. COMPETENCY - FORMULATE, ANALYZE, EVALUATE AND CREATE

1. Distinguish between longitudinal & transverse waves?

A.

Longitudinal waves	Transverse waves
1) Longitudinal waves are those whose particles of medium vibrate forward & backward about their mean position in the direction of wave motion to the direction of wave propagation. **Ex :** Sound waves travelling in air.	1) Transverse waves are of those in which the particles move about their mean position in the direction perpendicular to wave propagation. **Ex :** Water ripple on the surface of water.

2. Explain what is reverberation and how can it be reduced ?

A. Sound produced in a big hall persists for a long time due to repeated reflections from the walls of the hall still it is no longer audible. This persistence of sound due to repeated reflection of sound is called reverberation. Excessive reverberation is highly undersirable in auditoriums and big lecture and music halls. In order to reduce excessive reverberation, the roof and walls of the halls/auditorium are covered with sound absorbing material like drapries, thermocol, fibre board, rough plasted etc. Seats are made cushion type to effect absorption of sound when hall has lesser number of persons to absorb sound.

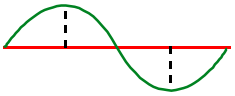
3. Distinguish between loudness and intensity.

A. Loudness of sound is measure of response of the ear to the sound. Loudness depends upon the intensity of sound (sound energy per unit area per unit time) and also upon sensitivity of the ear. Two sounds of equal intensity falling upon the ears of two persons may appear to be having different loudness. However more the intensity, louder the sound.

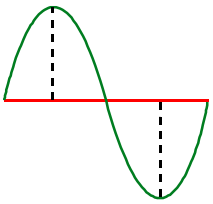
Therefore besides sensitiveness of the ear, the loudness of sound depends upon all factors upon which intensity of sound depends. Intensity of sound and hence loudness depends upon the square of amplitude. It also depends upon the area of vibrating body and density of air. More the density, louder the sound.

4. Draw the sketches of two waves A and B such that wave A has twice the wave length and half the end.

A.



Wave - A



Wave - B

5. A sound producing body is at considerable distance from a man. There can be four different media W,X,Y and Z between the sound producing body and the man. The medium X-brings the sound to man most Quickly where as medium Z tekes maximum time. The time taken by medium W in bringing sound to man is less than that of X but more then that of The medium y, however, fails to bring the sound from the sound producing body to the man which medium could be the one:

a) Having no fixed shape and no fixed volume ?

b) Having a fixed volume but no fixed shape ?

c) Having the same composition use that on the moon ?

d) Having a fixed shape and a fixed volume ?

A. a) Z b) W c) Y d) X

6. A loud sound can be heared at a large distance but a feeble or soft sound cannot be heard at a large distance Explain why ?

A. Sound is a form of energy which is transferred from one place to another place. As sound energy is directly proportional to the square of the amplitude of a vibrating body, so loud sound has large energy, whereas soft sound has small energy. As the sound travels through a medium, sound with large energy is absorbed after travelling a small distance in the medium but sound with large energy will be absorbed after travelling a large distance in the medium Therefore, loud sound can be heard at a large distance but feeble sound cannot be heard at a large distance.

7. Guess, which sound has a higher pitch : guitar or a car horn ?

A. Though car horn is louder than guitar but guitar has higher pitch than car horn. Frequency of guitar is higher than that of car horn.

8. If any explosion takes place at the bottom of a lake, what type of shock waves will take place ?

A. Explosion will result in production of compression and refraction i.e., longitudinal waves.

9. Why do we hear the sound produced by humming bee, while the sound of vibration of pendulum is not heard ?

A. Frequency of pendulum is less than 10 Hz and hence it produces infrasounds which are inaudible to human being. The sound produced by wings of the bee is within audible range and hence can be heard.

10. Why is a bell provided with a big outer case ?

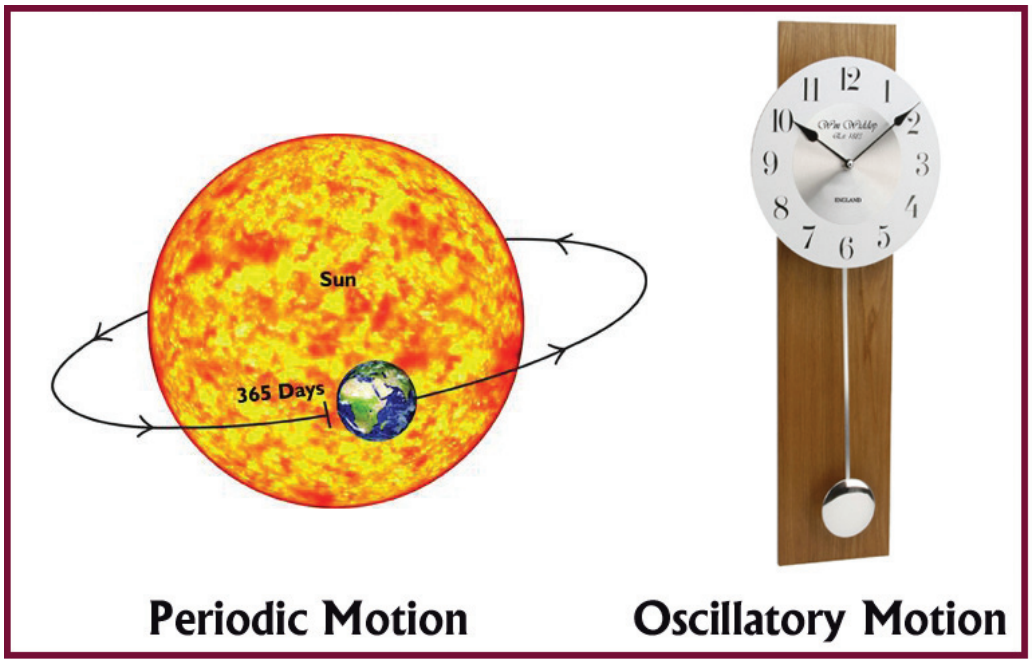
A. A bell is provided with a big outer case to produce loud sound. When the bob at the centre of the bell strikes the outer case, the case begins vibrating and due to its large surface area, a large volume of air is displaced producing a loud sound.

11. Two astronauts on the surface of the moon can not talk to each other Explain why ?

A. Since there is no atmosphere on the surface of the moon (i.e., no medium for the propagation of sound), So the sound cannot travel from one astronaut to another astronaut on the surface of the moon.

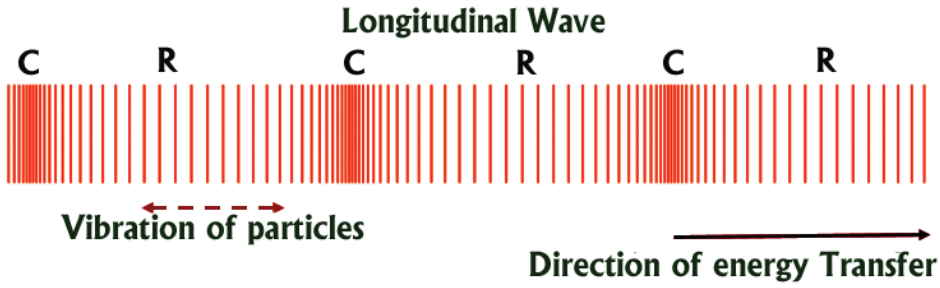
QUICK REVIEW

- **Periodic Motion :** The motion which repeats itself in equal intervals of time, is called periodic motion
- **Oscillatory Motion :** If a body moves to and fro repeatedly about a mean position, its motion is said to be oscillatory motion.



- **Wave :** A wave is a pattern of disturbance which travels through a medium due to repeated vibrations of the particles of the medium.
- **Wave Motion :** The disturbance being handed over from one particle to the next. The motion of the disturbance is called wave motion.
- **Transverse waves :** These are the waves in which the particles of the medium vibrate in a direction perpendicular to the direction of wave motion.
- **Longitudinal waves :** These are the waves in which the particles of the medium vibrate along the direction of wave motion.
- **Longitudinal wave :** Consists a series of compressions and rerefractions.
  - Compression is the region where the particles of medium are close to each other.
  - At compression, medium possess maximum density and high pressure.

- Rerefraction is the region where the particles of medium are far from each other.
- At Rerefraction, medium possess minimum density and low pressure.



➢ **Sound :** Sound is a form of energy which produces the sensation of hearing in our ears.
- Sound is produced due to vibration of different objects.
- Sound travels as a longitudinal wave through a material medium.
- Sound travels as successive compressions and rarefactions in the medium.
- In sound propagation, it is the energy of the sound that travels and not the particles of the medium.
- Sound cannot travel in vacuum.

➢ **Oscillation :** The change in density from one maximum value to the minimum value and again to the maximum value makes one complete oscillation.

➢ **Wave length :** The distance between two consecutive compressions or two consecutive rarefactions is called the wavelength, λ

➢ **Time period :** The time taken by the wave for one complete oscillation of the density or pressure of the medium is called the time period, T.

➢ **Frequency :** The number of complete oscillations per unit time is called the frequency (ϑ), $\vartheta = \frac{1}{T}$.
- The SI unit of frequency is hertz" (Hz)

➢ **Speed of sound :** The distance travelled by the sound wave in a given medium per unit time is called speed of sound.
- The speed v, frequency ϑ, and wavelength λ, of sound are related by the equation $v = \lambda\vartheta$.
- The speed of sound depends primarily on the nature and the temperature of the transmitting medium.

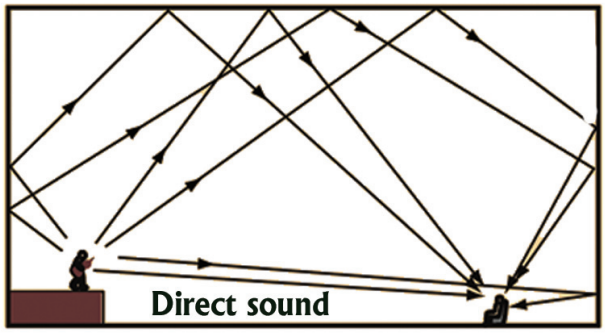
  Speed of sound in air $\rightarrow$ 343 m/s

  Speed of sound in water $\rightarrow$ 1481 m/s

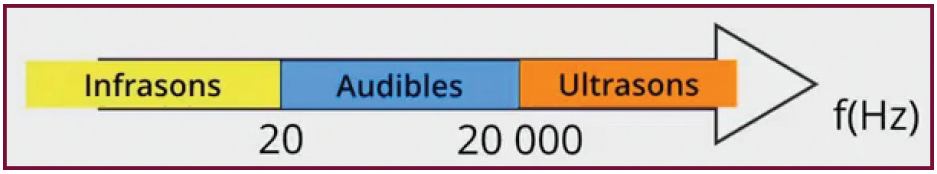
  Speed of sound in iron $\rightarrow$ 5120 m/s

➢ **Amplitude :** Amplitude is the maximum displacement from their mean positions during the wave propagation.

- **Laws of reflection :** The law of reflection of sound states that the directions in which the sound is incident and reflected make equal angles with the normal to the reflecting surface at the point of incidence and the three lie in the same plane.
  - For hearing a distinct sound, the time interval between the original sound and the reflected one must be at least 0.1 s.
- **Reverberation :** The persistence of sound in an auditorium is the result of repeated reflections of sound and is called reverberation.



- Sound properties such as pitch, loudness and quality are determined by the corresponding wave properties.
- Loudness is a physiological response of the ear to the intensity of sound.
- The amount of sound energy passing each second through unit area is called the intensity of sound.
- Echo is the phenomenon of repeatation of sound due to its reflection from the surface of a large obstacle
- The persistence of sound in an auditorium is the result of repeated reflections of sound and is called reverberation.
- The sound which has a pleasing sensation to the ears is called music
- The sound which has a unpleasing sensation to the ears is called noise.
- The sound of a single frequency is called a tone.
- A notation representing the pitch and duration of a musical sound is called musical note.
- Human ear is sensitive to frequencies between 20 Hz to 20,000 Hz, is called audiable range.
- Sound waves with frequencies less than 20 Hz are called Infrasonic waves
- Sound waves with frequencies with greater than 20,000 Hz are called Ultrasonic waves.



- Ultrasound has many medical and industrial applications.

ANALYSE AND APPLY

1. The audiable range of human ear is _____ Hz to _____Hz
2. Sound wave is example to _____ wave.
3. Sound is produced due to _____ of objects.
4. _____ sound has many applications in medical and industries.

5. Sound can travel through vaccum (T/F)

6. SONAR technique is used to determine the depth of sea (T/F)

7. Loudness of a sound is depends on frequency of the wave (T/F)

8.

	Physical Quantity		S.I unit
i)	Wavelength	p)	Hz
ii)	Frequency	q)	s
iii)	Time period	r)	s^{-1}
iv)	Amplitude	s)	m

9.

	Column - I		Column - II
i)	Pitch	p)	multiple reflections
ii)	Loudness	q)	determined by frequency
iii)	Quality	r)	determined by wave form
iv)	Reverberation	s)	effect produced in brain by sound.

10.

	Column - I		Column - II
i)	Music	p)	Single frequency
ii)	Noice	q)	Combination of several frequencies
iii)	Tone	r)	Pleasing sensation
iv)	Note	s)	Unpleasing sensation

OBJECTIVE EXERCISE

Multiple choice questions :

1. Sound waves do not travel through : [ ]
   a) Solids b) liquids c) gases d) vacuum

2. Which of the following will remain unchanged when a sound wave travels in air or in water
   a) Amplitudle b) Wavelength c) Frequency d) Speed [ ]

3. On a slinky we can produce : [ ]
   a) Transverse waves only b) Longitudinal waves only
   c) Both transverse and longitudinal d) Neither transverse nor longitudinal waves.

4. The walls of a hall built for musical concert should : [ ]
   a) amplify sound b) reflect sound c) transmit sound d) absorb sound

5. In an orchestra the musical sounds of different instruments are distingushed from one another by the characteristic of : [ ]
   a) loudness b) pitch c) quality or timbre d) all of these

6. The bells of a temple are made of large size. It is for : [ ]
   a) Producing sound of high pitch b) Producing loud sound
   c) Producing sound of high quality d) Enhancing the beauty

7. The loudness of a sound depends upon : [ ]
   a) Amplitude b) Pitch c) Velocity d) Wavelength

8. As day of mechanical piano struck gently and then struck again but much harder this time. In the second case : [ ]
   a) Sound will be louder but pitch will not be different b) Sound will be louder and pitch will also be higher
   c) Sound will be louder but pitch will be lower d) Both loudness and pitch will remain unaffected.

9. Sound travels in air if : [ ]
   a) particles of medium travel from one place another
   b) There is not moisture in the atmosphere
   c) Disturbance moves
   d) Both particles as well as disturbance travel from one place to another.

10. When we change feeble sound to loud sound we increase its : [ ]
    a) frequency b) amplitude c) velocity d) wavelength

11. Earthquake produces which kind of sound before the main shock wave begins : [ ]
    a) ultrasound b) infrasound c) audible sound d) none of the above

12. Infrasound can be heard by : [ ]
    a) cat b) bat c) rhinoceros d) human beings

13. Sound cannot travel through [ ]
    a) Air b) Vacuum c) Oxygen d) None

14. Speed of sound is more in [ ]
    a) Solids b) Liquids c) Gases d) Vaccum

15. Sound waves are ———— waves [ ]
    a) Transverse – mechanical waves b) Transverse – non mechanical waves
    c) Longitudiuanal – mechanical waves d) Longitudinal – non mechanical waves

16. Stethescope works on the principle of [ ]
    a) multiple reflection b) Diffraction c) both a and b d) Resonance

17. Bats make use of [ ]
    a) Infrasonic sound b) Ultrasonic sound c) Subsonics d) none

18. Velocity of sound is miniumum in ———— [ ]
    a) Steel b) Air c) liquids d) Vaccum

19. The audible ranges of hearing for average human beings is ———— [ ]
a) 20 Hz - 20000 Hz b) 20 kHz - 40 kHz c) 10 kHz - 20 kHz d) 20 kHz - 30 kHz

20. Speed of sound depends on [ ]
a) Temperature of medium b) Nature of medium
c) Elasticity of medium d) All the above

Assertion & Reason Tpye Questions :

a) Both A and R are correct and R is the correct explanation of A
b) Both A and R are correct but R is not the correct explanation of A
c) A is correct, R is incorrect d) A is incorrect, R is correct

21. **Assertion (A) :** Compression is a region of high pressure. [ ]
Reason (R) : When the vibrating particles come closer to one another than they normally are then there is a momentary reduction in volume and a compression is formed.

22. **Assertion (A) :** The distance between the centre of a compression and an adjacent rarefaction is equal to half the wavelength [ ]
Reason (R) : The minimum distance in which a sound wave repeats it self is called its wave length.

23. **Assertion (A) :** The frequency of a wave is the reciprocal of its time - period. [ ]
Reason (R) : 1 Hertz is equal to 1 vibration per second.

24. **Assertion (A) :** The sound of our voice is produced by the vibrations of two vocal cords in our throat [ ]
Reason (R) : The energy required to make an object vibrate and produce sound is provided by some out side source.

25. **Assertion (A) :** We cannot talk to one another directly on the moon as we do on earth through we may be very close. [ ]
Reason (R) : Sound cannot travel through vacuum.

OLYMPIAD CORNER

1. Which of the following wave is a longitudinal wave [ ]
a) radio waves b) sound waves
c) waves on the surface of water d) light waves

2. If temperature of air is increased, then the velocity of sound [ ]
a) decreases b) increases c) remains the same d) may decrease or increase

3. Distance between two adjacent crest and trough is 0.5 m. Wavelength of the wave is [ ]
a) 1 m b) 0.25 m c) 0.5 m d) 2m

4. Time period of a wave is 0.5 sec and its speed is 100 m/s. What is the wavelength of the wave ?
a) 200 m b) 100 m c) 50 m d) 5m [ ]

5. Audible range for human beings is [ ]
a) above 20 kHz b) below 20 Hz
c) between 20 Hz to 20 kHz d) none

6. When we say 'sound travels in medium', we mean [ ]
a) the particles of medium travel b) the source travels
c) the disturbance travels d) the medium travels

7. A sound wave consists of [ ]
a) a number of compression pulses one after the other
b) a number of rarefaction pulse one after the other
c) compression and rarefaction pulses one after the other
d) a compression and a rarefaction usually separated by a distance equal to one wavelength

8. The time period of a sound wave travelling in a medium is T. At a given instance (t = 0) a particular region in the medium has minimum density. The density of the region will be minimum again at
a) t = T b) t = T/2 c) t = T/3 d) t = T/4 [ ]

9. Hertz stands for [ ]
a) second b) second^{-1} c) metre d) metre^{-1}

10. The frequency of a source is 20 kHz. The frequencies of the sound waves produced by it in water and air will [ ]
a) be the same as that of the source
b) depend upon the velocity of the waves in these media
c) depend upon the wavelength of he waves in these media
d) depend upon the density of the media

11. If the density of air at a point through which a sound wave is passing is maximum at an instant, the pressure at that point will be [ ]
a) minimum b) same of the density of air
c) equal to the atmospheric pressure d) maximum

12. The properties of ultrasound that make it useful are [ ]
a) high power and high speed b) good directionality and high power
c) high speed and frequency
d) good directionality and ability to move around objects1

13. Doctors can produce images of internal organs with help of [ ]
a) Infrasound b) Ultrasound c) Audioble sound d) All the above

14. The speed of sound in air at 0°C is approximately [ ]
a) 332 ms^{-1} b) 1450 ms^{-1} c) 5100 ms^{-1} d) 3×10^8 ms^{-1}

15. If the frequency of a wave is 330 Hz, and velocity of wave in air is 330 ms^{-1}, then the wavelength of the wave is [ ]
a) 0.5 m b) 1 m c) 2 m d) non certain

16. The minimum distance required for producing echo is [ ]
a) 1.7 m b) 17 m c) 10 m d) 300 m

17. Shyamal was calculating the velocity of wave using a slinky. He asked his teacher regarding the features of spring to be used. The teacher replied that the spring should be [ ]
a) Long, soft and flexible b) Short, soft and flexible
c) Short, hard and flexible d) Long, soft but not flexible

18. Factors affecting the velocity of sound are [ ]
a) density of the medium b) amplitude of sound waves
c) temperature of the medium d) both a and c

1. Motion

Multiple Choice Questions :

1) a	2) a	3) c	4) c	5) b	6) c	7) a	8) b	9) b	10) c
11) b	12) b	13) d	14) c	15) c	16) d	17) a	18) b	19) b	20) a
21) b	22) c	23) c	24) a	25) d					

Olympiad Corner :

1) d	2) d	3) c	4) d	5) a	6) a	7) a	8) d	9) a	10) a
11) d	12) c	13) a	14) d	15) b	16) c	17) b	18) a	19) b	20) c

2. Force and Laws of Motion

Multiple Choice Questions :

1) a	2) c	3) b	4) a	5) d	6) b	7) c	8) b	9) b	10) a
11) a	12) a	13) c	14) a						

Olympiad Corner :

1) a	2) d	3) d	4) c	5) c	6) c	7) c	8) c	9) b	10) c
11) b	12) d	13) b	14) d	15) b	16) c	17) b	18) c	19) a	20) a

3. GRAVITATION

Multiple Choice Questions :

1) c	2) b	3) d	4) c	5) a	6) d	7) b	8) c	9) b	10) b
11) a	12) a	13) b	14) a	15) a	16) a	17) d	18) d	19) a	20) d
21) d	22) a	23) b	24) d						

Olympiad Corner :

1) b	2) c	3) b	4) b	5) d	6) c	7) a	8) a	9) d	10) b
11) d	12) d	13) d	14) b	15) b	16) a	17) a	18) b	19) a	20) c

4. Work and Energy

Multiple Choice Questions :

1) c	2) a	3) d	4) a	5) d	6) c	7) d	8) d	9) c	10) c
11) c	12) c	13) c	14) b	15) a	16) c	17) c	18) a	19) a	20) b
21) c	22) d	23) c	24) a	25) c	26) c	27) d	28) a	29) d	30) a

Olympiad Corner :

1) d	2) a	3) d	4) d	5) d	6) d	7) a	8) d	9) c	10) a
11) d	12) d	13) a	14) d	15) d	16) c	17) d	18) d	19) c	20) d

5. SOUND

Multiple Choice Questions :

1) d	2) c	3) c	4) d	5) c	6) b	7) a	8) a	9) c	10) b
11) b	12) c	13) c	14) a	15) c	16) a	17) b	18) d	19) a	20) d
21) a	22) d	23) b	24) a	25) a					

Olympiad Corner :

1) b	2) b	3) a	4) c	5) c	6) c	7) c	8) a	9) b	10) a
11) d	12) b	13) b	14) a	15) b	16) b	17) a	18) c		